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MEDIASTINAL PLEURISY IN INFANTS*

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INTRODUCTION

VARIATIONS in the contour of enlarged thymus gland shadows are so numerous that the significance of distinctly atypical shadows is frequently overlooked. Pleurisy does occur in the anterior superior mediastinal area, and gives shadows similar to, but differing from, the thymus gland in many respects. Pleurisy involving the mediastinal and adjacent visceral pleurae is usually difficult to detect by physical signs and routine roentgen procedures. Most of the diagnostic difficulties can be accounted for by the depth and density of the mediastinum, its normal variations in contour, and the variety of pathological processes which can occur within or adjacent to it.

LITERATURE

The roentgenological aspects of this form of pleurisy in infants have received little attention in the literature. The original observations were all reported in foreign journals, and include the reports of Pincherle[6] in 1925, Reyher[7] in 1928, Saupe[9] in 1933, Engel and Schall[3] in 1933, and Gefferth[4] in 1939. Shanks, Kerley and Twining[10] in their recent English "Text-Book of X-Ray Diagnosis" published in 1938 have referred to a previous report[3] for coverage of this subject in infants. Pertinent findings in the foreign reports will be discussed later in this paper. This form of pleurisy has received little recognition in this country, and this is probably the result of (*a*) English abstracts of the original papers not including graphic material; (*b*) the low mortality associated with this form of pleurisy preventing postmortem confirmation of reports in the literature; (*c*) the lack of well known differential features between this type of pleurisy and thymus gland enlargement, and (*d*) the poor roentgen technique in infant cases.

The various forms of mediastinal pleurisy with and without effusion which have been described in the literature have been assembled in diagrammatic form in Figure 1. All of these sites and forms are duplicated by many disease processes and structural abnormalities. Area 2 is of greatest interest in this paper. Figure 2 shows some of the locations of these pleurisies and effusions in another plane at mid-chest level. The contours are schematic, and can vary in amount and shape in different diseases and levels in the chest.

PATHOLOGICAL ANATOMY

The mediastinum separates the right and left pleural cavities and contains vital structures connecting with the neck and

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abdomen. It is covered laterally with pleura which is continuous with costal and diaphragmatic pleurae. The sternum forms its anterior boundary, and the thoracic vertebral column forms its posterior boundary. Within the mediastinum are such structures as the heart, great vessels, trachea, bronchi, esophagus, nerves, thymus gland, lymphatic trunks, and nodes. Chronic and

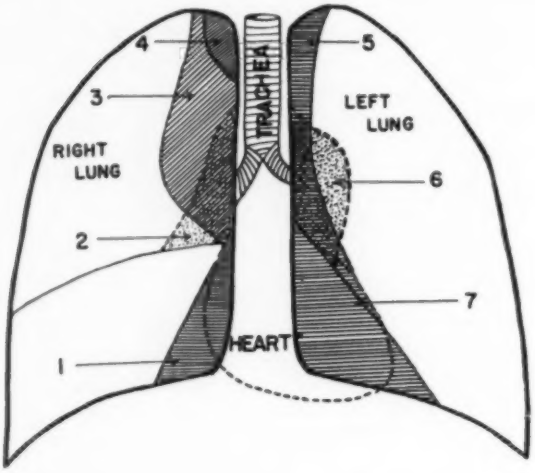


FIG. 1. Schematic drawing of the thorax showing the seven areas of localization of mediastinal pleurisy reported in the literature.

acute infections frequently involve many of these structures, and occasionally the limiting sternum or spine. These infections may remain localized to one structure, spread to an adjacent one, or give rise to diffuse involvement of the mediastinal area—all with some possible degree of pleural involvement. Infections of the neck region may extend downward to involve the mediastinum. Subdiaphragmatic infection is sometimes associated with diaphragmatic or mediastino-diaphragmatic pleurisy and adjacent pneumonitis.

Infections within the lungs frequently give rise to associated processes in the adjacent visceral pleura, and in the bronchial and tracheobronchial lymphatic systems.

Thus, pleurisy involving the mediastinal and/or visceral pleurae can arise from pathological changes within the lungs, within the mediastinum, within the lungs and mediastinum simultaneously, or from primary processes in the neck or abdomen with extension to the mediastinal area.

DIFFERENTIAL DIAGNOSIS

Although the differential diagnosis in cases of suspected superior mediastinal pleurisy is mainly between pleurisy and thymus gland enlargement, there are many other conditions which may be confused. Among these are:

1. Partial atelectasis of the lung.
2. Pneumonic infiltration.
3. Stasis in the superior vena cava by pressure from an elevated bronchus.
4. Enlarged hilar nodes.
5. Infections of the thymus gland.
6. Tumors of the thymus gland.
7. Dilated left auricle.
8. Retrocardial aneurysm.
9. Paravertebral abscess.
10. Spondylitis deformans.
11. Esophageal diverticulum.
12. Dilated esophagus.
13. Scoliosis.
14. Pericardial fat tab.
15. Ganglioneuroma of the vagus nerve.
16. Tumor of the pericardium.

PRESENTATION OF CASES

Case 1 illustrates unilateral thymus gland enlargement, and is included for comparison, differentiation, and discussion. The re-

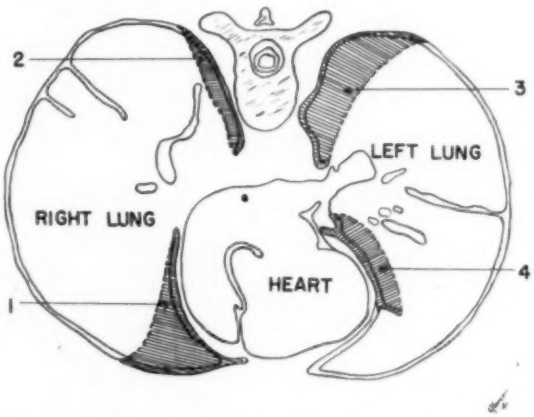


FIG. 2. Schematic drawing of a transection of the thorax at mid-chest level showing some of the possible localizations of mediastinal pleurisy in this plane.

maining 8 cases demonstrate forms of mediastinal pleurisy which have been encountered in patients under one year of age. Although 7 of these cases were thought to show thymus gland enlargement, there are many features in each case which would contradict such a diagnosis. The group is presented to define further the thymus problem.

Case I. E. R. R. was a ten week old male with a history of episodes of restlessness, hypertonicity, and irritability since birth. The physical findings were normal. Roentgenograms of the chest taken on October 28 and November 6, 1940 (Fig. 3) revealed right-sided thymus gland enlargement. Deep roentgen therapy (100 r) was administered to the anterior mediastinum on November 7 with the following factors: 200 kv., 25 ma., 0.5 mm. Cu, 1.0 mm. Al, and 50 cm. target-skin distance. The thymus shadow was reported absent from roentgenograms taken one week and also three months after the treatment. The infant has remained asymptomatic since treatment.

Case II. M. M. was a six week old female who had received mineral oil orally and had had irritability, feeding difficulties, and cyanotic spells several times a day for three weeks. On admission to the hospital her temperature was normal, white blood count was 9,600, and tuberculin skin test was negative. A chest roentgenogram taken on November 8, 1940 (Fig. 3) revealed pneumonia and an angular paramediastinal density on the right side. She was given 100 r of deep roentgen therapy to the anterior mediastinum on November 11, 1940. She was discharged from the hospital on November 27 slightly improved, although a chest roentgenogram still showed a pneumonic consolidation and the angular density.

This patient was seen many times in the clinic because of cough and noisy respirations during the following two months, and she was readmitted to the hospital on March 6, 1941, with a flare-up of the pneumonic process. The patient was given another 100 r of deep roentgen therapy to the anterior mediastinum on March 24, 1941. The pneumonic process gradually disappeared but there has been no significant change in the right paramediastinal angular shadow as judged by roentgenograms taken on March 27, April 4, May 29, and October 21, 1941. Repeated cultures have revealed no "causative" organisms, and a chronic pneumonitis on a lipoid aspiration basis is thought to explain the pneumonic processes.

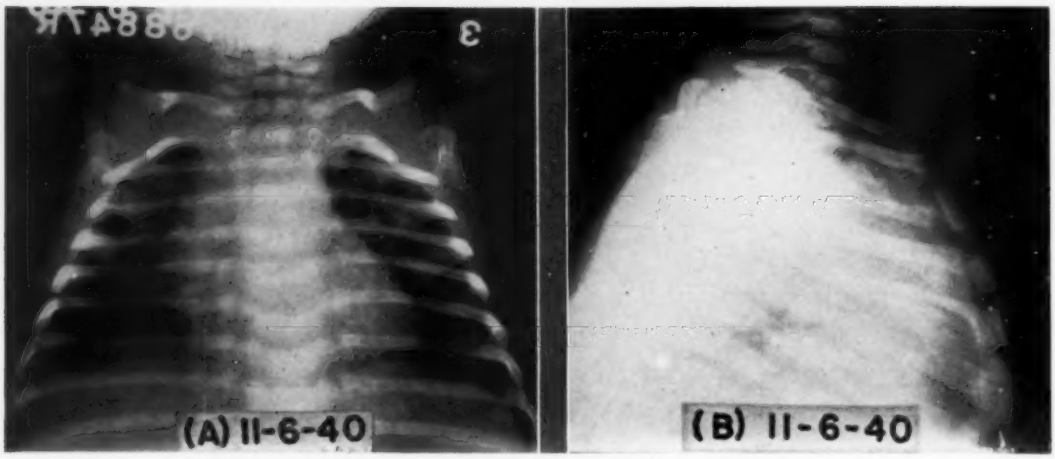
Case III. L. S., a male infant, was normal for the first two months of life. He was then admitted to another hospital in the city with signs of an upper respiratory infection, white blood count of 15,000, slight fever, and a negative tuberculin skin test. A roentgenogram of the chest was interpreted as congenital atelectasis of part of the right upper lung with reaction about the area. He was discharged from the hospital after ten days but returned to that clinic for the next month because of persistent cough. He was then taken to another institution where another chest roentgenogram was also interpreted as atelectasis.

Three months later he was first seen in this clinic with a history of chronic cough, and a more recent complaint of wheezing and grunting respirations during feeding. There had been no recognized fever or cyanosis since the original episode. Physical examination revealed dullness anteriorly to the right of the mediastinal border but no change in breath sounds. A chest roentgenogram taken on February 19, 1941 (Fig. 4) closely resembled those previously taken elsewhere. The patient was admitted to this hospital on February 22 with vomiting, diarrhea, a temperature of 39° C., white blood count of 14,200, and a negative tuberculin skin test. A chest roentgenogram taken on February 24 showed no change from the previous one. The patient remained a diagnostic problem, but was discharged from the hospital on March 1, 1941. He was brought back several times because of a fever and cough, and subsequent chest roentgenograms have revealed a gradual alteration in the shape and a final disappearance of the paramediastinal shadow previously observed.

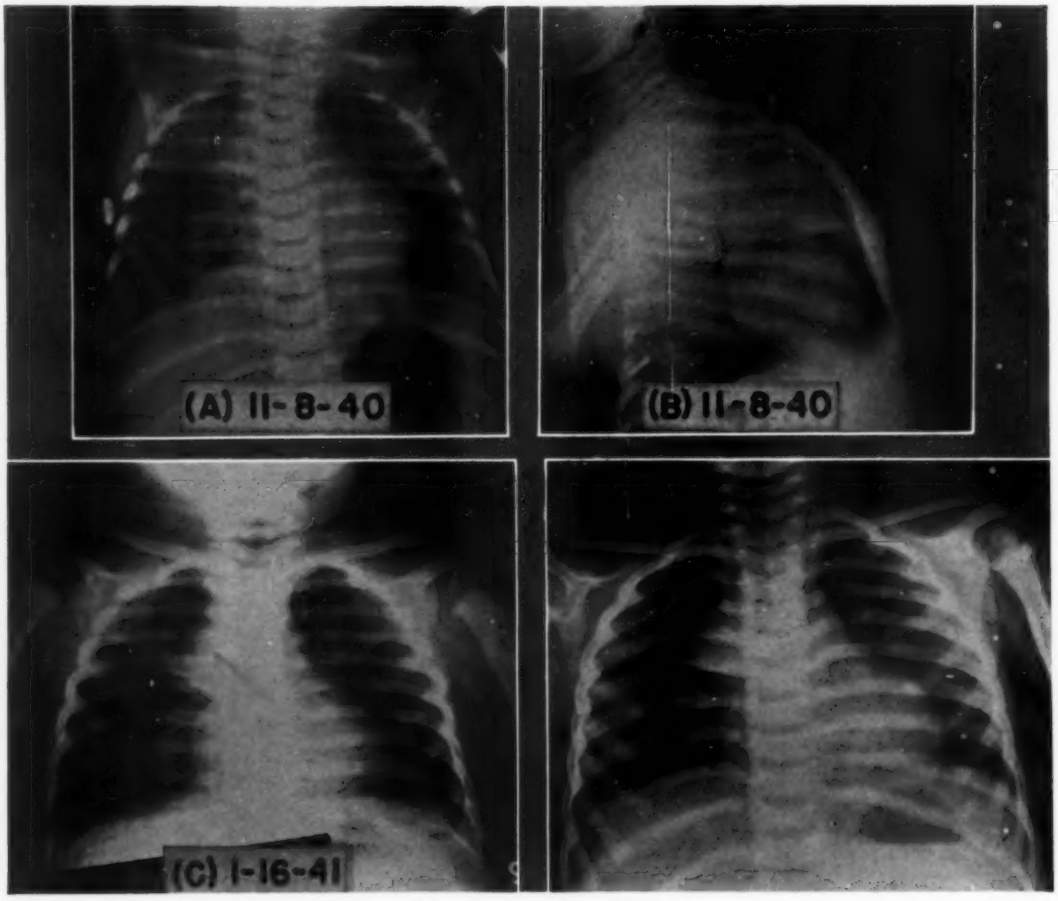
The patient was readmitted to the hospital on May 21, 1941, with signs of right upper lobe pneumonia, white blood count of 21,000, and Type VI pneumococci in the gastric washings. Sulfathiazol was effective in combatting the pneumonia, and he was discharged from the hospital on September 12, 1941.

Recently he has received an autogenous vaccine from his nasopharyngeal flora, and has been found allergic to chocolate. A bronchial asthma is thought to exist.

Case IV. W. R. was a normal male infant at birth, and he was well for three weeks. At that



Case I



Case II

Fig. 3. *A*, Case 1. An anteroposterior view of the chest showing right-sided thymic enlargement which extends below the right interlobar fissure to cap the upper cardiac shadow. *B*, Case 1. A lateral view showing increase in density in the superoanterior portion of the chest, and posterior deviation of the tracheal shadow which was persistent during roentgenoscopy and is accentuated here by the respiratory phase.

Comment: Subsequent examinations following roentgen therapy to the anterior mediastinum revealed

time he developed pneumonia in the left lung, and was admitted to the hospital on February 12, 1941, in an acutely ill state. His temperature was 38.3° C., white blood count was 36,000, and the tuberculin skin test was negative. Roentgenograms of the chest revealed a left central pneumonia and emphysematous changes in the upper and lower left lung areas (Fig. 5). Sulfathiazol had little effect. Roentgenograms of the chest during the next month showed very little change, bronchoscopy revealed "extrinsic pressure on the left bronchus as from adjacent atelectasis," and lung puncture cultures showed *Staphylococcus aureus haemolyticus*. The patient developed a small left hydrothorax, but about five weeks after admission, the pneumonic process appeared slightly less in extent. March 31, 1941, deep roentgen therapy, 100 r, was given to the left anterior chest, and 150 r was given to the left posterior chest on April 1, 1941. On April 2 he coughed up several mouthfuls of foul smelling green pus, and from this point on the left lung rapidly cleared except for the emphysematous changes. He did well for the next four months but then developed persistent cough. A roentgenogram of the chest taken on September 12, 1941, revealed a new triangular area of density along the right mediastinal border, and a persistence of emphysematous areas in the left lung. He was next seen on October 22, 1941, with more cough. A roentgenogram of the chest showed a decrease in the size of the angular density and considerable increase in the prominence of the pulmonic markings around that area.

Case v. D. W. was a male infant, two months old when he was admitted to the hospital with jaundice. A routine chest roentgenogram revealed a patchy increase in markings in the right upper lung field. Rotation in positioning was so extreme that the mediastinal area could not be satisfactorily studied. The tuberculin skin test was negative. The jaundice cleared gradually, and the patient was discharged three weeks after admission.

Three months later he was readmitted to the hospital with persistent cough and difficult breathing. Physical examination was not remarkable. The white blood count was 24,000, tuberculin skin test was negative, and a chest roentgenogram showed an angular shadow extending laterally from the right border ofthe mediastinum and pneumonic changes in the left lung (Fig. 5). Cultures showed a Type xiii pneumococcus. He improved with symptomatic treatment and was discharged from the hospital after ten days with his cough still present.

One month later he was seen in the clinic with a history of severe cough since discharge from the hospital. Another roentgenogram of the chest showed little change from the previous one.

The cough gradually decreased during the next five months. Roentgenoscopy of the chest at this time revealed the angular shadow to be considerably smaller.

Case vi. M. R. was born prematurely, grew satisfactorily for more than five months, and had had mineral oil administered orally for several weeks. She was admitted to the hospital as a feeding problem. Physical examination revealed a pneumonic process in the right upper lung, and a slight fever. The white blood count was 12,000, tuberculin skin test was negative, and a roentgenogram of the chest taken on September 29, 1941, revealed pneumonia in the right upper lung field and an angular density along the right upper mediastinal border (Fig. 6). Cultures revealed no "causative" organisms. The pneumonic signs cleared rapidly. A roentgenogram of the chest taken on discharge from

absence of the angular shadow in the anteroposterior view, and a return of normal radiolucency in the superoanterior portion of the chest in the lateral view. The tracheal shadow appeared straight in the lateral views.

Case ii. *A*, An anteroposterior view of the chest showing pneumonic densities in the right upper and lower lung fields, an angular density extending laterally from the mediastinum and limited inferiorly at the interlobar fissure region, and tracheal shift to the right.

B, lateral view showing a slight radiolucency beneath the sternum area, and an anterosuperior mediastinal chest density limited sharply at the interlobar fissure inferiorly.

C, posteroanterior view showing the angular density, persistence of increased lung markings, and tracheal deviations to the right.

D (right lower, 10-21-41), posteroanterior view showing a persistence of the angular density in spite of two previously administered deep roentgen therapy treatments.

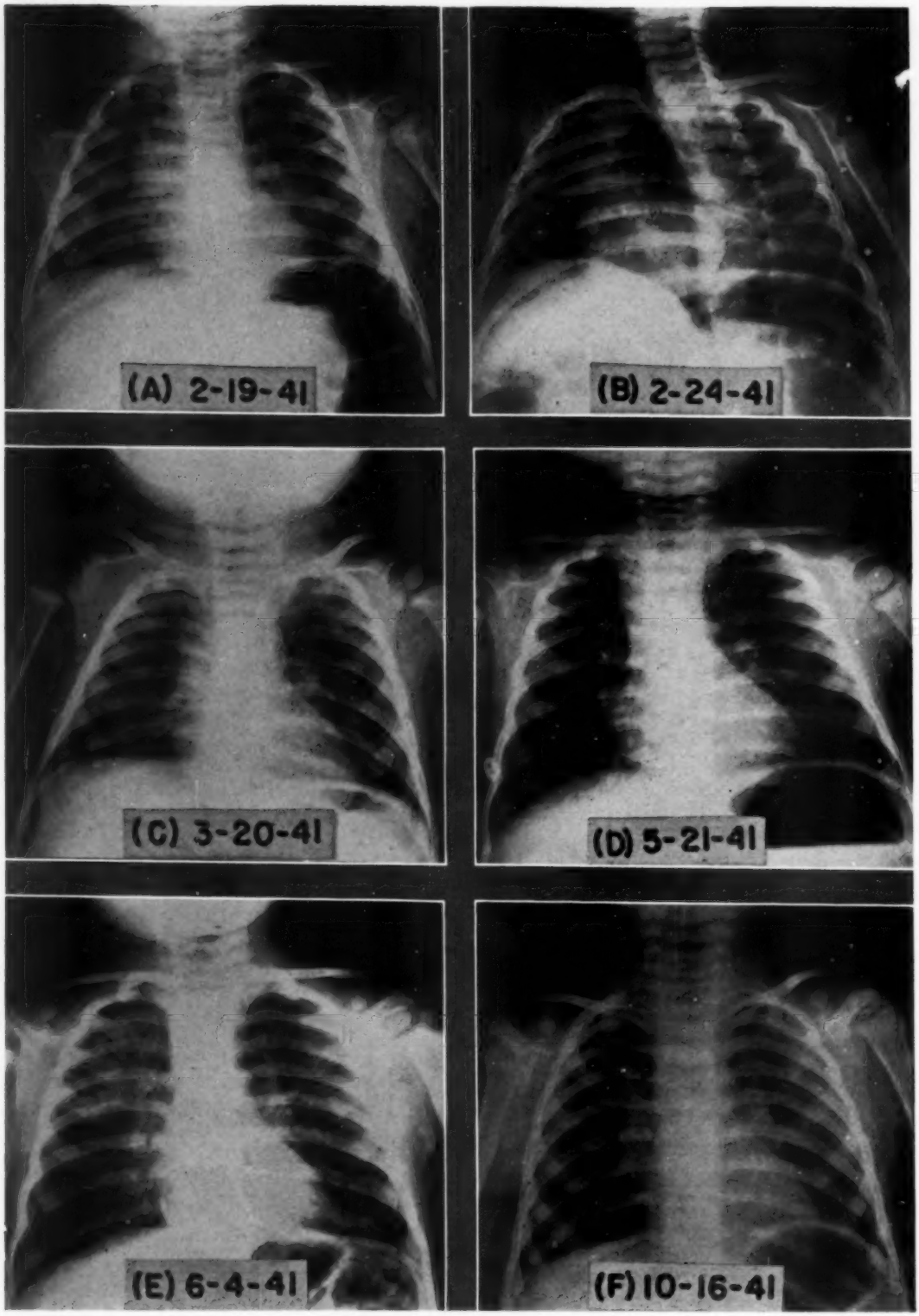


Fig. 4. Case III. *A*, posteroanterior view of the chest showing tracheal deviation to the right, an angular paramediastinal shadow on the right with sharp inferior limitation at the interlobar fissure, and increased lung markings.

the hospital on October 9, 1941, revealed clearing of the lung fields, but persistence of the right paramediastinal density. She was readmitted to the hospital on December 30, 1941, with a recurrence of the pneumonia in the same area of the lung, but the right paramediastinal density noted in the previous examination was no longer visible. Cultures again failed to reveal a "causative" organism. The pneumonic process has shown little tendency to subside during the past five weeks, and lipoid pneumonitis is suspected.

Case vii. J. R., a six month old male mongolian idiot, was admitted to the hospital on February 13, 1939, with measles and bronchopneumonia from which he recovered. He was discharged from the hospital on March 12, 1939. He was readmitted to the hospital during the next year with Type xvii pneumonia on one admission, and Type xix pneumonia on another admission. On March 8, 1940, he was admitted with a Type iv pneumococcal involvement of the left lower lobe of the lung. Roentgenograms also showed widening of the mediastinal shadow, and irregularity of both superior mediastinal borders which was thought to be due to effusion localized in this area (Fig. 6). Subsequent roentgenograms on March 11, 1920, showed a clearing of the pneumonic process and alteration in the configuration of the mediastinal shadow. The patient succumbed several months later from further pneumonic processes. An autopsy was refused.

Case viii. M. C. was born prematurely but grew normally for two months. Suddenly she developed a cough, fever, vomiting, and on the second day severe respiratory distress occurred. She was admitted to the hospital in a moribund condition, with a temperature of 36.5° C., a white blood count of 41,000, hemoglobin of 7.9 grams, an enlarged heart, and signs of pneumonia at the left lung base. A chest roentgenogram showed an enormous increase in the heart shadow, an angular density projecting laterally from the right mediastinum into the interlobar fissure, and increased lung markings in the left lung (Fig. 6). She was started on sulfathiazol and nasal oxygen, but died seven hours after admission.

The autopsy revealed a small amount of clear amber fluid within the abdominal cavity, 15 cc. of clear amber fluid within the pericardial sac, a 55 gram heart, moderate hypertrophy of the myocardium, marked thickening of the endocardium, numerous fibrous adhesions along the middle and lower right mediastinal pleural border, fibrous adhesions in the central portion of the right interlobar fissure, and mild pulmonary congestion. Microscopic study showed fibrous thickening of the endocardium, numerous lymphocytes in the region of the pleural adhesions, and pulmonary congestion. Chemical studies failed to establish glycogen storage disease.

Case ix. M. M., a two month old male inveloped an ear infection which required a six day hospitalization. He remained free from symptoms for three weeks, and was then readmitted to the hospital on March 6, 1939, with fever, a white blood count of 15,300, physical and roentgenographic signs of pneumonia with Type xxii pneumococci in the sputum, and a negative tuberculin skin test. He became afebrile with sulfapyridine therapy. The patient received 100 r of deep roentgen therapy to the anterior mediastinum on March 14, 1939, for suspected concurrent right thymus enlargement, and was discharged from the hospital free of symptoms on March 17, 1939.

For the next seven months he was followed in another clinic for asthma, the chief symptom being wheezing at night. He was readmitted to

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B, oblique view showing the anterior position of the paramediastinal density. Note the relation to the interlobar fissure.

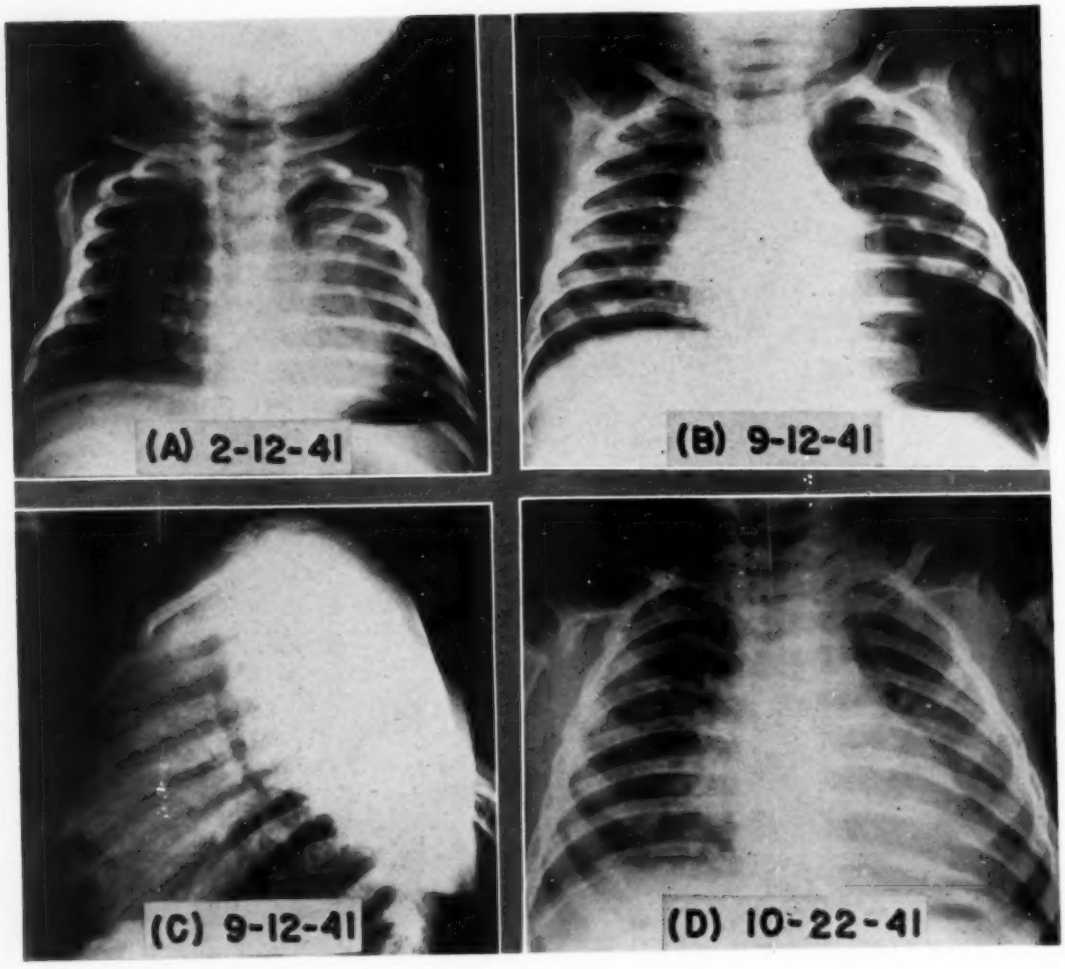
C, posteroanterior view showing change in shape of the density and persistence of increased markings.

D, posteroanterior view showing further alteration in the shape of the density, and increased lung markings particularly in the central region. Note inferior angle of the density and its relation to the medial portion of the interlobar fissure.

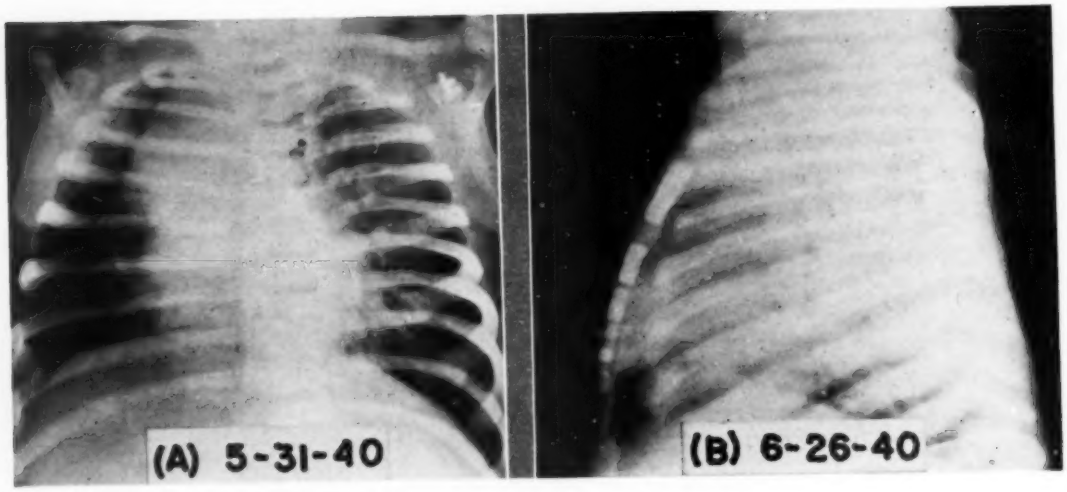
E, posteroanterior view showing a pneumonic process in the right upper lung field, absence of the previously described angular density, and increase in density of the interlobar fissure.

F, posteroanterior view showing bilateral increase in central lung markings, and continued absence the angular density.

Comment: The course of this case and the illustrations closely resemble a case of "questionable thymus gland enlargment" presented by Gerstenberger.[5]



Case IV



Case V

Fig. 5. Case iv. *A*, posteroanterior view of the chest showing pneumonic and emphysematous changes in the left lung field.

the hospital with fever, white blood count of 10,300, roentgenographic signs of left upper lobe pneumonia, and the persistence of right-sided angular paramediastinal density. Type XXII pneumococci were numerous in the cultures. Sulfapyridine therapy was effective in combatting the pneumonia.

Figure 7 is a schematic representation of the various configurations of the pleurisies presented by the preceding cases.

DISCUSSION

Although only one of these cases presented as illustrations of mediastinal pleurisy has had a postmortem examination, they all closely resemble proved cases presented by other authors. This form of pleurisy has been encountered exclusively in young children. Pincherle[6] has reported finding 30 cases of mediastinal pleurisy in 2,000 routine roentgen chest examinations in young children, or an incidence of 1.5 per cent. The cases described in this paper and 2 more recently observed would suggest a similar low incidence here.

Clinically there is no single or group of symptoms that would permit a definite diagnosis of mediastinal pleurisy, even with effusion, without a roentgenogram of the chest. Cough is the most common symptom, 6 of the 8 cases reported here having had a history of prolonged cough. Usually these cases are pneumonic in origin, frequently showing recurrences of pneumonic infection, and some cases being more specifically designated as "pleuropneumonia."[8] The pneumonic recurrences affect the related lobes of the lung more often than lobes on the opposite side of the mediastinum from the original pleurisy. Five of the cases just reviewed had several recognized pneumonic episodes, 2 cases had a single known pneumonia simultaneously with or prior to the appearance of the pleural process, and 1 case had no known pneumonic history. Physical findings are usually related to the pneumonic processes rather than to the pleurisy or effusion. In Case III, definite widening of the anterior mediastinum was detected by percussion, and this is the only case in this group in which variation in mediastinal size or contour was suspected prior to roentgenography. Mineral oil had been administered orally to 2 of the cases in this series, and the lung changes in Case II and Case VI were thought to be due to lipoid pneumonitis. The tuberculin skin test was repeatedly negative in all of the cases in this series.

The course of these cases is relatively benign as evidenced by the low mortality in this series to date. The 2 deaths so far in this group of 8 cases give an inaccurate mortality rate of 25 per cent, because Case VIII died of cardiac disease primarily, and Case VII was complicated by mongolian idiocy. Reyher[7] reported 1 death in 26 cases of mediastinal pleuritis. His fatal case was a three month old infant, and the process was tuberculous.

The treatment of these cases has been symptomatic except for the pneumonic recurrences which have had sulfonamide therapy. Diagnostic or therapeutic aspiration of possible fluid present has been suggested, but this was not resorted to in any

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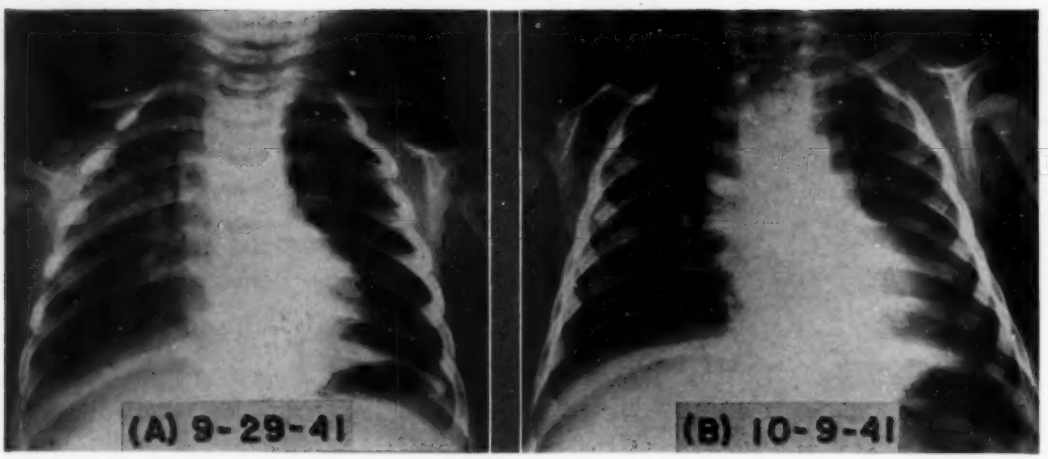
B, posteroanterior view showing the degree of clearing of the left lung field, persistence of emphysema, and the appearance of a new triangular density along the right mediastinal border.

C, lateral view showing the anterior distribution of the previously noted density, and its sharp inferior limitation at the interlobar fissure.

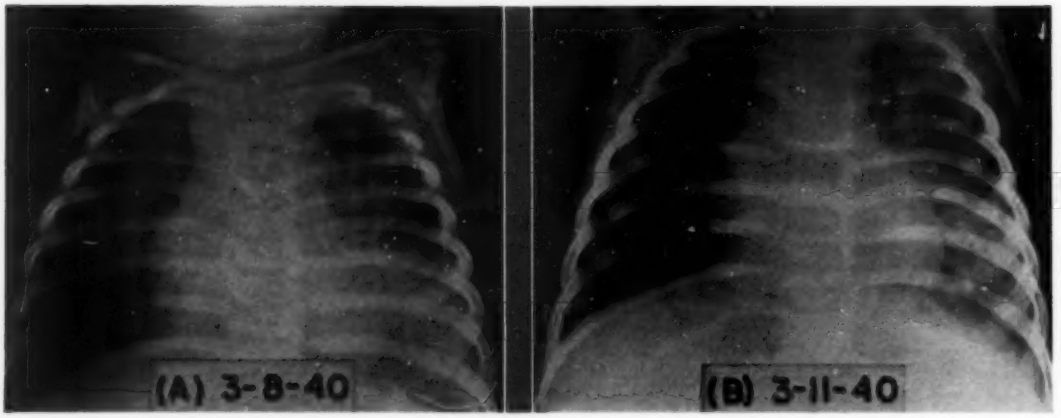
D, posteroanterior view showing reaction in the previously noted area of angular density.

Case V. *A*, anteroposterior view of the chest with some rotation. The angular density off the right mediastinal border is continuous inferiorly with the interlobar fissure. Pneumonia is present in the left lung field.

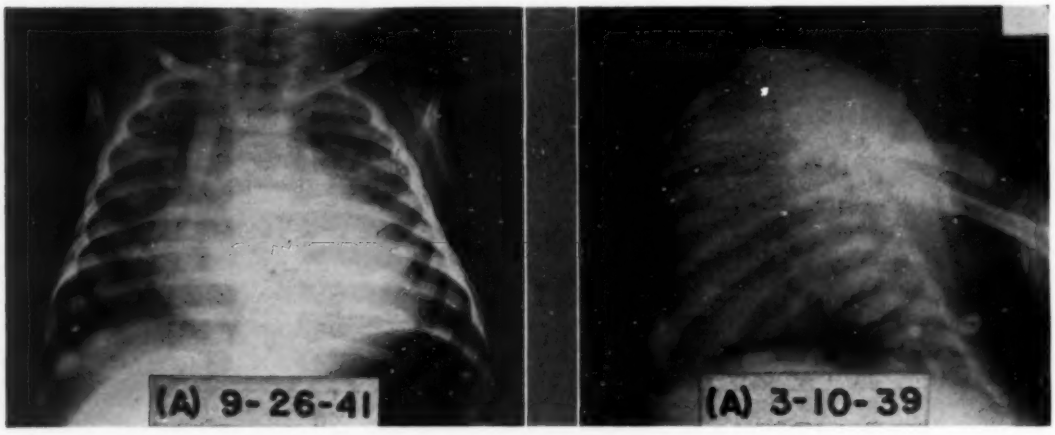
B, lateral view showing the anterior location of unusual density, its sharp inferior border, and its decreasing intensity superiorly.



Case VI



Case VII



Case VIII Case IX

Fig. 6. Case vi. *A*, posteroanterior view of the chest showing pneumonia in the right lung field, and a right paramediastinal density associated inferiorly with the interlobar fissure. *B*, posteroanterior view showing clearing of the pneumonia and slight change in the contour of the paramediastinal density.

of these cases. Therapeutic drainage would be in order in the presence of empyema. Roentgen therapy directed to the anterior mediastinum has not permanently altered the appearance, or significantly shortened the course of the disease in the 2 cases in which it was tried (Cases II and IX).

The pathological changes occurring in this type of case have common findings, as judged by recorded autopsy findings.[3] When fluid is present it is serofibrinous, and the associated pleurisy is of fibrinous or fibrous character which serves to localize the fluid. A residual thickened pleura persists for an undetermined time after disappearance of the fluid. Bigler[1] has reported finding fibrous adhesions frequently along the mediastinal pleura at autopsy on children without previously recognized pleurisy from the clinical standpoint. In general, the predominance of right-sided lesions has been explained by the larger number and immediate subpleural location of the right tracheobronchial and bronchial lymph nodes as contrasted with the fewer and deeper placed nodes on the left side. Of all the infections which could involve these anterior nodes, tuberculosis is apparently rare. Buckley[2] examined 115 tuberculous cases with known mediastinal involvement and found only 2 cases with evidence of this infection in the anterior group of nodes.

Bacteriologically, the following organisms were recovered from the sputum, gastric washings, or lung punctures during the acute pneumonic stages in 5 of the cases reported in this paper:

Type VI pneumococcus (1 patient)
Type XIII pneumococcus (1 patient)
Types IV, XVII, and XIX pneumococcus, a different single type being recovered during each separate illness (1 patient).
Type XXII pneumococcus recovered during two separate illnesses (1 patient).
Staphylococcus aureus haemolyticus (1 patient)

Of the remaining 3 cases, 2 failed to show "causative" organisms, and the pneumonic processes were thought to be due to lipoid aspiration; the third never had a known pneumonic infection.

Postmortem cultures of fluid present are reported to be sterile, except when pneumococcal, staphylococcal, or tuberculous empyema occurs, the latter being found more frequently in older patients.

The roentgen recognition of this form of pleurisy is important, but the criteria which are used to distinguish it from unilateral thymus gland enlargement are not generally known. This form of mediastinal pleurisy with or without effusion is characterized by or associated with:

1. A sharp lateral margin.
2. Ends in an inferior angle of less than 90° and in relation with or near the interlobar fissure.
3. Usually unilateral and more often present on the right side than on the left side.
4. Frequent inflammatory changes in the adjacent lung parenchyma.
5. Increase in the width and density of the interlobar fissure shadow.
6. Greatest density is inferior in the lateral projection.

Case VII. *A*, anteroposterior view of the chest showing pneumonia in the left lung field, bilateral widening of the superior mediastinal shadow, and a double angular contour of the left border of the mediastinum. *B*, anteroposterior view showing decrease in the pneumonic process, and a change in contour of the left mediastinal border.

Case VIII. *A*, posteroanterior view of the chest showing enormous cardiac enlargement, increased markings in the left lung field, and a small angular density extending from the mediastinal area laterally into the interlobar fissure.

Case IX, *A*, lateral view of the chest showing a sharply marginated density in the superior and anteromedial aspect of the chest. Note the clear space in the retrosternal area.

Comment: The remainder of the roentgenograms of this case are not reproducible at this time, but the posteroanterior views do show a right sided angular paramediastinal density similar to Case II (*C*) in Figure 3.

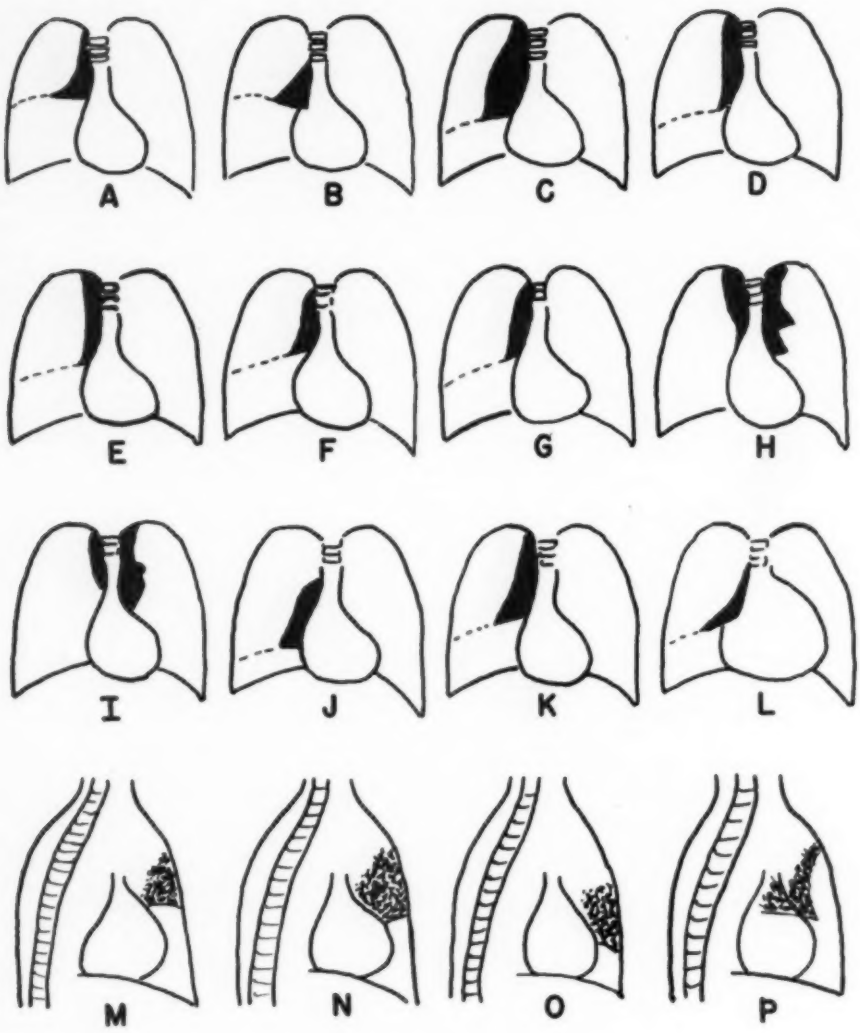


Fig. 7. A schematic representation of the areas of pleurisy demonstrated in Cases II through IX.

Drawing	*Case*
A	II
B	II
C	III
D	III
E	III
F	VI
G	VI
H	VII
I	VII
J	IV
K	V
L	VIII
M	II
N	IV
O	V
P	IX

7. The density may be anywhere between the anterior and posterior boundaries of the pleural space in the lateral projection.
8. No tracheal deviation or distortion in the lateral projections. Persistent lateral deviation to the affected side in the postero-anterior views in 2 cases in this series.
9. Minimal changes in the size and contour of the density during quiet or labored respiration.
10. No significant reduction in size after small doses of roentgen therapy.

In contrast to the preceding criteria, significant thymus gland enlargement is characterized by:

1. A larger shadow which overlaps part of the cardiac shadow.
2. Rounded corners, usually 90° or more.
3. Considerable change in contour with respiration and crying.
4. More often bilateral, although asymmetries and unilateral forms are well known.
5. Variable degrees of tracheal and esophageal deviation or compression in one or both planes. This point is still widely disputed in the literature.
6. Always anterior and superior in lateral projections.
7. Decreases in size after small doses of roentgen therapy.

It is possible to have both pleurisy and thymus gland enlargement simultaneously. Improvement in symptoms following a roentgen treatment without evidence of much reduction in the angular shadow is possible in that thymus tissue present and obscured by the pleural density could be reduced so as to allow shift or redistribution of any fluid present. Occasional reports of roentgen resistant thymus glands should be checked for possible misinterpretations of the findings.

The greatest source of error arises from poor positioning or alignment in roentgenography. Slight rotation of the patient may completely obscure portions of the mediastinal border. Low positioning of the tube accentuates these angular deformities and in 2 of these cases, the residual thickened pleura cast a solid triangular shadow from this angle. Correct alignment in these same cases showed only linear shadows representing thickened pleura in the central interlobar fissure area. This thickening was a residual characteristic of all the cases which cleared of their major density during the period of observation.

CONCLUSIONS

1. Atypical appearing thymus gland shadows and cases of so-called roentgen resistant thymus gland should be reappraised with mediastinal pleurisy foremost in the differential considerations.

2. Mediastinal pleurisy is found in 1 to 2 per cent of routine roentgen chest examinations in children under one year of age.

3. Infants having prolonged, atypical, or repeated pneumonic symptoms should be examined for the existence of mediastinal pleurisy.

4. Pleurisy of this form was associated with pneumococcal infections of the lungs in four cases in this series, and with suspected lipoid pneumonitis in two cases. Frequent recurrences of pneumonic infection were noted.

5. Treatment of the cases reported was symptomatic except for specific therapy of the initial or recurrent pneumonic processes.

6. Diagnostic or therapeutic aspiration for any fluid present was not attempted in this series.

7. Roentgen therapy directed to the mediastinal area in two cases did not shorten the course of the process.

8. Residual linear pleural thickening in the central interlobar fissure region was noted after clearing of the pleurisy, and it appeared as a solid triangle when poor alignment occurred in roentgenography.

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STUDY OF THE "WIDENED" MEDIASTINUM IN CHILDREN AND PITFALLS IN DIAGNOSIS*

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INTRODUCTION

THE investigation of which this paper is the result grew out of the realization that a number of infants and children were being kept as patients at this institution solely because of roentgenographic evidences of "widened mediastinum" or "enlarged" mediastinal and tracheobronchial lymph nodes. In some cases, the children had been hospitalized for one to three years (Cases I, II, III) with no evidence of active tuberculous involvement of the lung parenchyma, with negative sputa, negative gastrointestinal examinations and no further clinical evidence of disease other than a positive tuberculin reaction, which is representative of a healed as well as an active infection. Some of the patients previously had had definite clinical and roentgenographic evidence of pulmonary tuberculosis but, long after the parenchymal lesion had completely resolved, discharge from the hospital was delayed because of apparent tuberculous mediastinal lymphadenitis.

During this period, the children had been roentgenographed in the horizontal position, a practice which is still prevalent in most institutions. The probable reason for the extensive use of this faulty technique is that it is apparently easier to place an infant or small child on the table on top of the cassette, and then make an exposure. For the past seven years, however, the senior author had been roentgenographing the chests of all infants and children at another institution in the upright position, and during this time, had often had occasion to note the marked variation in the width of the mediastinal shadow when films taken in the horizontal and upright positions were compared. Because of this experience, upright chest roentgenography was instituted as a routine procedure in the Pediatric Pavilion at Sea View Hospital.

As a result, a considerable number of children have been discharged because of sudden restitution of the mediastinal shadow to normal. It must be emphasized that this return to the normal of the mediastinum occurred, not by virtue of healing or shrinkage of enlarged mediastinal or paratracheal nodes, but solely because of an altered or improved technique of roentgenographic examination.

Although the work herein described has been primarily in the field of "initial infection" or "childhood" tuberculosis, the subject has a very much wider application. Indeed, it is our feeling that the interpretation of any chest roentgenogram of the infant or young child is subject to grave error unless the film has been taken according to a correct technique and unless the various factors that may alter the size and appearance of the heart and mediastinal shadow are fundamentally understood. What these several factors are will be brought out and elaborated upon in the body of this communication, under the head of "Discussion."

The proper interpretation of what constitutes a normal mediastinal shadow on the roentgenogram has long been the subject of much discussion and investigation. Krause[16] in 1924 wrote, "Enlargement of the mediastinum or chronic mediastinitis runs through x-ray reports, especially those of children's examinations, like a song, with a monotony that makes one wonder whether mediastinal changes are not the normal in the young." The reason for this statement and for the confusion it depicts is that most chest films are made in the

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horizontal position. If children's chests were routinely roentgenographed in the upright position, there would be no occasion for a statement of this character. The interpretation of what constitutes a normal mediastinum would then be no more difficult in children than in adults.

The technique of upright roentgenography in infants and children is by no means a new concept, though it has never been generally adopted. Remer and Belden,[25] as far back as 1927, employed this technique but in their method it was necessary for both the patient and cassette to be held by an attendant. It often requires a high degree of acrobatic skill to hold an uncooperative crying child or infant properly, without having to hold both cassette and patient. Pancoast and Pendergrass[23] later devised a chair with a built-in cassette holder which in principle is not unlike our device. This was an adaptation of their encephalographic technique and was employed by them chiefly for roentgenography of the neck and thymus. In 1931, one of us (A.V.S.) had occasion to see at the Willard Parker Hospital, a cassette holder for upright chest roentgenography built by Kohn and Koiransky,[15] and it was this apparatus which served as a model for the modified and improved device which we built. The device will be described later but it may be said at this point that with it, all infants and children, including the newborn, can be roentgenographed with much greater ease in the upright than in the horizontal position. Wood[28] also described a "frame for holding infants upright" in 1934, which serves essentially the same purpose. An apparatus for upright roentgenography has also been described by Engel and Schall.[8]

Although roentgenologists and pediatricians alike are generally cognizant of the differences in the size of the heart and mediastinum that exist with upright and horizontal roentgenography, in many cases the knowledge is of an academic rather than practical character, since horizontal chest roentgenography for children is still carried out in most institutions. In discussing the matter with several experienced clinicians, the answer is usually, "Yes, we know, it is nothing new," but nevertheless, they are almost invariably surprised when shown roentgenograms of the same child, made at the same time but with the two different techniques (upright and horizontal).

It is almost superfluous to point out the great benefits to both the patient and the hospital if the period of hospitalization can be significantly reduced. This applies particularly to institutions for the care of tuberculous children, because such cases are often kept for several years. As regards the patient, once having arrested his disease, he is best out of the hospital since he is unquestionably less subject to further exposure and leads a more normal life in a home environment that harbors no open case of tuberculosis. With hospital budgets strained as they are and with long lists of patients waiting for admission, the advantages for the hospital in reducing the period of institutional care are obvious.

In institutions for the hospitalization of tuberculous children, their stay will without doubt be shortened if the mediastinum appears normal rather than widened due to faulty technique. In general hospitals not limited to tuberculosis, the avoidance of incrorrect diagnoses by adoption of an upright technique is too advantageous to require extended comment.

ANATOMY

Generally speaking, the anatomy of the mediastinum is fairly well known to most of us, especially as it appears on the roentgenogram. However, the appearance of the mediastinal shadow may undergo marked variation, depending on the technique and manner in which the roentgenograms are taken. In order to understand the reason for this and to better appreciate its importance and application to the interpretation of children's chest roentgenograms, it is worth while reviewing the anatomy of the mediastinum.

The mediastinum lies between the two pleural sacs and is bounded anteriorly by the sternum

and posteriorly by the vertebral column. It is then subdivided into the superior, anterior, middle and posterior mediastinum, the contents of each being:[6]

1. The *superior*, bounded by the sternum anteriorly, the first four thoracic vertebrae posteriorly, laterally by the mediastinal pleurae, and below by an imaginary line drawn from the inferior border of the fourth thoracic vertebra to the inferior border of the sternum, its contents being the aortic arch and its three great branches the innominate veins and part of the superior vena cava, trachea, esophagus, thoracic duct, phrenic, vagi and cardiac nerves, the thymus, and left recurrent nerve.
2. The *middle*, containing the heart, pericardium, phrenic nerves and associated vessels.
3. The *anterior*, containing fibro-areolar tissue which lies between the pericardium and sternum and the lymph glands.

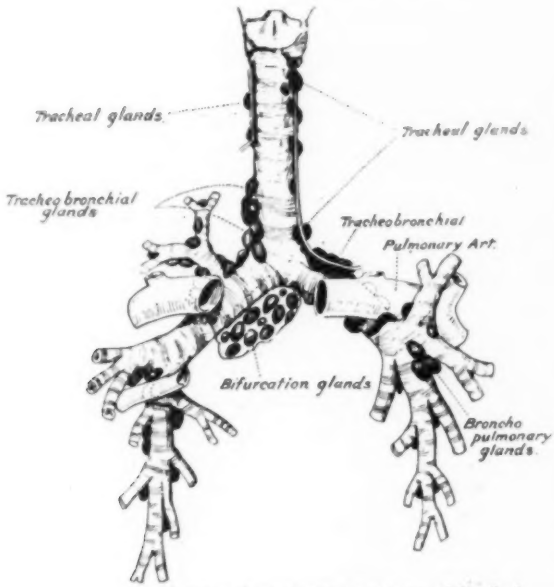

Diagram: Lymph nodes of the tracheobronchial tree. (Sakiranikow.)

Fig. 1

4. The *posterior*, bounded by the pericardium and vertical portion of the diaphragm, anteriorly; posteriorly, by the last eight thoracic vertebrae; and laterally, by the mediastinal pleurae containing the descending thoracic aorta, intercostal branches, azygos, hemiazygos, and accessory hemiazygos veins, thoracic duct, esophagus and the two vagi.

Roentgenographically, the mediastinal and heart shadow borders are also known. The right border ordinarily is formed by the right auricle below, ascending arch of aorta, the superior vena cava and innominate vein (when dis-

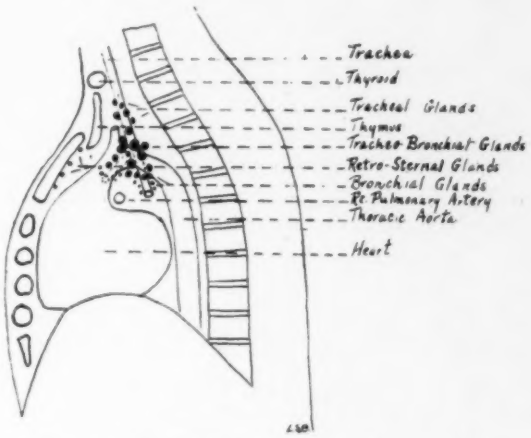

Fig. 2. Left sagittal section of infant thorax.

tended as in the horizontal position). The left border from below upward is formed by the left ventricle, left auricular appendage, the pulmonic conus and the aortic knob. According to Margolies,[18] the left border of the supra-aortic portion of the superior mediastinum is formed by the soft tissue shadows of the left common carotid and subclavian arteries.

The trachea lies in the midline and bifurcates at the level between the third and fifth dorsal vertebrae. The aorta lies in the middle of the mediastinum and it passes upwards and turns backwards, passing down behind the heart. The shadow of the thymus is triangular, its base overlapping the base of the heart, especially the auricles. The mediastinal lymph glands lie along the trachea, paratracheally and along its bifurcation (Fig. 1). Bigler,[3] in his careful dissection of the lung, found that lymph nodes were present in every hilum, the larger nodes at the hila and the smaller towards the periphery. He concluded that the normal nodes do not cast shadows on the roentgenogram and that nodes in the hilum or in intrapulmonary tissue, caseous or inflammatory, cannot be recognized if they do not contain calcium, or are large enough to encroach on the pulmonary fields, or are embedded in air-bearing parenchyma, the contrast of which renders them

visible. In relation to the sagittal diameter of the chest, the trachea, its glands, the veins (superior vena cava and azygos group) and the branches of the aorta in this area lie closer to the anterior surface of the body than to the posterior. This is illustrated in Figure 2, and the anterior position of these structures has an important bearing on the roentgenographic technique adopted, as will be brought out later.

METHOD

The procedure adopted in this study was as follows: 25 patients ranging in age from newborn to eleven years were selected and 10 of these had eight successive roentgenograms taken in the following positions:

1. Anteroposterior horizontal, at end of expiration
2. Anteroposterior horizontal, at end of inspiration
3. Posteroanterior horizontal, at end of expiration
4. Posteroanterior horizontal, at end of inspiration
5. Anteroposterior upright, at end of expiration
6. Anteroposterior upright, at end of inspiration
7. Posteroanterior upright, at end of expiration
8 Posteroanterior upright, at end of inspiration

In the remaining 15, films only in the upright and horizontal posteroanterior positions, in the same phase of respiration, were taken. All films were taken at 36 inch distance and 1/30 second exposure, only the voltage being varied to suit the thickness of the chest being roentgenographed. Thus, all films are directly comparable since the factors of distortion and magnification are constant. Case VII (Fig. 21–28) illustrates the eight positions utilized.

Only 7 of the 25 cases are included in this article, since they illustrate the salient points, and only in Case VII are all eight roentgenograms presented. In the remaining cases, to conserve space, only the most significant roentgenograms are shown. In addition to the 25 cases included in the special study, there were a great many isolated cases in which the anteroposterior horizontal and posteroanterior upright were available for comparison. The variations present between the two roentgenograms in some of the cases were so great as to cause doubt whether both roentgenograms were of the same patient. This, of course, was checked and verified.

As a result of study in the various upright and horizontal positions, it was almost invariably found that the roentgenograms made in the posteroanterior upright position at the end of inspiration were the most satisfactory and gave the least distorted and least misleading views of the heart and mediastinum. If, in addition, a method of synchronizing the exposure with the same phase of the cardiac cycle is employed, successive roentgenograms on different days are absolutely comparable, particularly in regard to heart size and shape. We have often noted two chest roentgenograms of a stereoscopic pair which showed marked changes in size and configuration of the heart. Obviously, in such a case one roentgenogram was taken in systole and the other in diastole.

DISCUSSION

Changes in the size and appearance of the mediastinal and heart shadows on the roentgenogram may be produced by various factors, among which the most important are position (whether horizontal or upright), the effect of gravity, the phase of respiration and the phase of the cardiac cycle. The changes so produced are neither trivial nor unimportant, since they may be responsible for serious mistakes in diagnosis. Thus, we have seen chest roentgenograms that were entirely normal diagnosed at various times as hypertrophied thymus, childhood tuberculosis, congenital or acquired valvular heart disease, enlarged heart and even bronchopneumonia, where none existed. These mistakes are easily made unless one understands the effect of the above mentioned factors in producing the alteration in the roentgenogram.

Effect of Position and Gravity. Great variation in the size of the mediastinum has long been recognized and ascribed to change in position.[22–25]. In the cadaver, Cunningham[6] states that owing to the weight of the heart, the anterior mediastinum is increased and the posterior mediastinum reduced in the anteroposterior depth. From this, it can be inferred that the mediastinal structures can move in anteroposterior direction because of available space and the force of gravity. In the supine position (anteroposterior) the mediastinal structures tend to drop posteriorly. Because of the bony character of the vertebrae, there is no yielding space posteriorly and, as a result, the structures spread laterally, pushing the lungs before them. The amount of lateral displacement, though not great, is appreciable, as the roentgenograms demonstrate.

In the prone (posteroanterior) position, the mediastinal structures move anteriorly. Again, the mediastinum tends to spread laterally, but owing to the soft compressible fibro-areolar tissue and the space in the anterior mediastinum, it more nearly approaches the sternum and the lateral displacement is minimal. Thus, it may be stated that in the horizontal position, the posteroanterior (prone) view will produce a narrower mediastinal shadow than the anteroposterior (supine) view. This is due also to another important factor which holds true for both the horizontal and upright positions, namely that the trachea, its lymph nodes, heart and vessels all lie closer to the anterior surface of the body than to the posterior (Fig. 2). Thus, when the cassette is placed against the anterior part of the chest, as in the posteroanterior view, these structures lie closer to the film and undergo less distortion and magnification than if they were farther from the film as in the anteroposterior position.

Still another important rôle in increasing the width of the mediastinal shadow in the horizontal position can be ascribed to the abdominal organs. These tend to push up the diaphragm, thus shortening the vertical diameter of the thorax and causing lateral expansion of the mediastinal structures, including the heart. Again, in the horizontal position, widening is added to by distention of the large blood vessels (superior vena cava and innominate vein on the right, and subclavian vessels on the left).

In the upright position, all these factors produce the opposite effect. The blood vessels empty, the abdominal viscera drop, removing their pressure on the diaphragm, and the mediastinum tends to recede inferiorly. In doing so, the lateral displacement is minimized and the mediastinal shadow is correspondingly narrowed. It may thus be stated that all other factors being constant, the posteroanterior upright position is the one calculated to produce the narrowest and least misleading shadows of the heart and mediastinum on the roentgenogram.

Effects of Respiration. The mechanism of repiration in changing the size of the mediastinal and heart shadows has had various explanations. Groedel and Dietlen[11] are of the opinion that descent of the diaphragm produces inspiratory narrowing and the ascent produces expiratory widening. Holzknecht and Hofbauer[12] found widening throughout inspiration (which is contrary to other reports and our own findings). Dietlen admits a widening in early inspiration due to sudden filling of the superior vena cava and right auricle as the result of suction effect. This mechanism has been studied to a great extent by Manges,[17] who also demonstrated that the crying effort influences the size of the heart and mediastinum. With normal breathing, the thoracic cavity grows smaller and the diaphragm rises as the air is gradually expelled during the repiratory phase.

As the thoracic cavity diminishes in length with the rising diaphragm, the heart is lifted and tilted so that the apex is swung farther to the left and the base farther to the right. The transverse diameter of the heart, therefore, increases during this phase and the projected cardiac shadow occupies a proportionately greater area at expiration than it does at inspiration. He further

showed that the reverse is true as far as the heart shadow is concerned, during the forced expiration incidental to the crying effort (Valsalva effect). The narrowed glottic chink offers a decided resistance to the column of air as the infant forcibly contracts the chest to increase the volume of sound. The intrapulmonary pressure is raised as a result and the heart swings on its long axis, the apex coming forward and the base backward. Its narrower diameter is therefore presented; the projected area is lessened for the greater part of this phase and is only broad for a moment, at the extreme end of expiration. Thus, in the crying child, unless one makes the exposure at this final instant of expiration, he will find the transverse cardiac diameter less than at inspiration, even though the chest has narrowed and the diaphragm has risen.[9]

During inspiration, as noted above, the heart and mediastinum, because of pressure changes and rotation of the heart, actually appear smaller. In addition, the thoracic cavity is enlarged and the pulmonic fields become wider so that the heart and mediastinal shadows appear even narrower in proportion. It is a common experience to observe the measurable differences in the size of the heart and mediastinum when roentgenograms, taken a few minutes apart, in inspiration and expiration, are compared (Fig. 19 and 20).

Another important point not directly related to this study merits brief consideration. During expiration, the lungs and particularly the bases are compressed by the rising diaphragm and contraction of the chest wall. In the horizontal position, the abdominal organs further displace the diaphragm upward, so that rather marked diminution in aeration of the lung bases may appear on the roentgenogram. The small pulmonary vessels become distended and the lung markings become prominent. These seen on end, against the background of relatively hypoventilated lung, may produce an appearance simulating bronchopneumonia (Fig. 23).

Often the cardiac shadow shows marked differences in the same individual on successive roentgenograms taken in the same position and the same phase of respiration. It is not an uncommon experience to find pronounced changes in the heart size and shape on the two films of a stereo pair, taken an instant apart. It is obvious that the cardiac cycle and the changes produced by systole and diastole must be considered in explaining this variation. This was studied by McPhedran and Weyl[20] in 1927. As a result, they synchronized exposures with the various phases of the cardiac cycle and were thus able to obtain roentgenograms showing the differences in the size of the heart. By synchronizing their exposures with the late diastole, they were able to eliminate artefacts and secure finer detail. We have on numerous occasions observed marked changes in the size of the heart which could have been due only to changes in the phase of the heart cycle, since examinations were made in the same position and phase of respiration. When, in addition to this factor, we consider the changes in heart size and shape that may occur due to the horizontal position and to phase of the respiratory cycle, it becomes apparent how unreliable cardiac measurements, particularly in children, may be if roentgenograms are taken at random with an unstandardized technique. The size and shape of the heart should be judged only in comparison with previous or subsequent teleroentgenograms made in the upright posteroanterior position, in inspiration, and using short exposures (1/10 sec. or less). If, in addition, means are available to synchronize the exposure with a particular phase of the cardiac cycle, the likelihood of error is reduced to a minimum. Common sense indicates, therefore, that in viewing roentgenograms not made under standard conditions, exact cardiac measurements are a delusion, and considerable latitude should be allowed in the judgment of cardiac enlargement or pathologic alteration of contour.

Relation of Mediastinal Shadow to Thymus. Many of the previous studies of the

mediastinum were made in relation to its bearing on the question of thymic enlargement. This is easily understood when it is considered that a so-called widened mediastinal shadow has often been mistakenly diagnosed as "hypertrophied thymus." We believe that no such diagnosis should be based on mere widening of the mediastinal shadow, especially if the roentgenogram has been taken only in the horizontal position. We have seen shadows that were diagnosed on horizontal roentgenograms as representing thymic enlargement, completely or almost completely disappear on roentgenograms taken in the upright position.

There is little doubt that many children have been unnecessarily given roentgen therapy for thymic enlargement because of errors in diagnosis due to roentgenograms made in the horizontal position. The width of the supposed thymic shadow (actually normal mediastinum) also varies with the phase of respiration, being wider on expiration and narrower at the end of inspiration, as well as being influenced by whether the infant is quiet or crying and the type of crying, i.e. regular or irregular. It was Pancoast[22] who wisely set up the criteria that "unless there are clinical evidences and lateral x-rays of the neck to show definite buckling of the trachea, it is impossible to make a diagnosis of enlarged thymus." To this can be added that no such diagnosis should be based solely on horizontal roentgenograms. Roentgenoscopic study, too, yields valuable information and its importance should not be overlooked. Correct positioning of the patient and roentgen tube is also essential in taking roentgenograms to demonstrate the thymus. The thymic shadow may appear either to one side or the other by incorrectly focusing the central ray or by failure to place and maintain the patient in the exact center of the cassette.[3] The thymic shadow may become greatly diminished in size or it may entirely disappear when the head is held in extreme dorsal flexion.

REPORT OF CASES

Case 1. D. M., colored female, aged two, who two months before admission developed a mild non-productive cough and slight evening fever. The child was taken to Board of Health for routine check-up and as a result was admitted to the hospital on February 7, 1938. The past history was essentially negative and the contact was found to be the father who died of pulmonary tuberculosis in December, 1937.

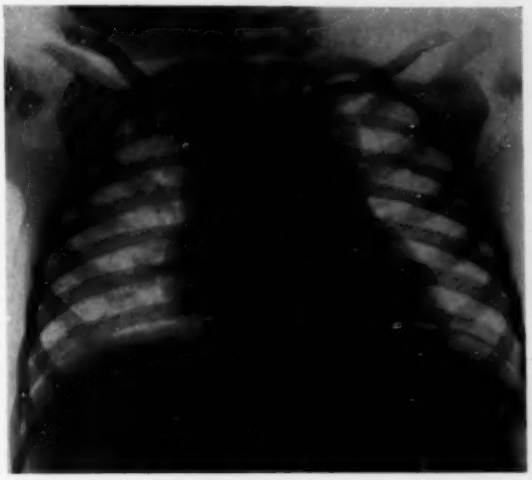

Fig. 3. Case 1. Admission roentgenogram, February, 1938, reveals bilateral widening of the mediastinal shadow.

On admission, physical examination revealed a well developed, fairly well nourished two year old colored female. The cervical glands were enlarged to a little more than twice their normal size. The heart was essentially negative. The lungs revealed slightly increased breath sounds on the right. The tonsils were hypertrophied and cryptic. The Pirquet test was positive, with tuberculides seen around the reaction. The liver edge was palpable 1.5 cm. below the costal margin.

Laboratory Data. Urine negative except for few leukocytes. Wassermann reaction negative. Sputum, gastric contents and feces negative for tubercle bacilli. Weight 26 lb., temperature 99–101° F., erythrocyte sedimentation rate 30 mm. per hour. Roentgenogram of chest revealed widened mediastinum (Fig. 3).

Course. By October, 1938, there were no further elevations in temperature, patient was gaining weight and the erythrocyte sedimenta-

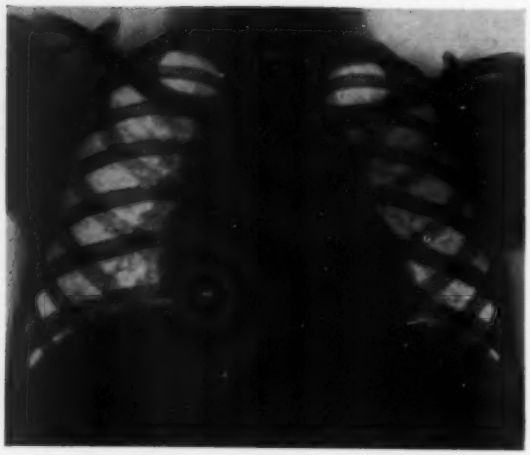

FIG. 4. Case 1. Expiratory posteroanterior horizontal roentgenogram three years later (March 15, 1941) still shows marked increase in mediastinal and heart shadows. Patient might have been hospitalized indefinitely on the basis of these findings.

tion rate was normal (8 mm.). The gastric findings remained negative and the chest roentgenogram apparently still showed enlarged mediastinal glands. Though the patient's general condition consistently improved, with no signs or laboratory evidence of clinical activity, she was kept in the hospital because of supposed enlargement of the mediastinal nodes until December, 1940, when an upright posteroanterior roentgenogram was made and a striking reduction of the mediastinal and heart shadow to normal became evident. As a result, the patient was discharged but remained in the hospital until April 2, 1941, because of difficulty in finding a home for her.

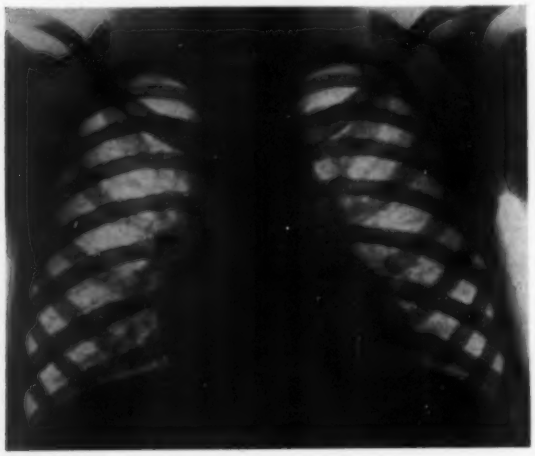

FIG. 5. Case 1. Expiratory posteroanterior upright roentgenogram, taken at the same time as Figure 4. Note decrease in width of mediastinal shadow and change in cardiac configuration as a result of upright position.

Comment. This patient obviously entered the hospital with the initial infection tuberculosis as evidenced by the elevated temperature, sedimentation rate, positive Pirquet test at age of two years and roentgenographic evidence of enlarged mediastinal nodes. By October, 1938, however, all clinical and laboratory evidence of activity had disappeared and the patient might have been discharged except for apparent enlargement of the mediastinal nodes as seen on the roentgenogram. Figures 4, 5 and 6 were all taken at the same time on March 15, 1941, and illustrate the striking differences in the width of the mediastinum and configuration and size of the heart, solely as a result of different roentgenographic technique.

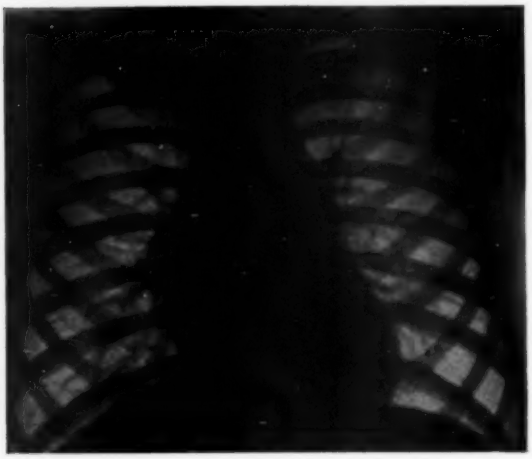

FIG. 6. Case 1. Inspiratory upright posteroanterior roentgenogram, taken at the same time as Figure 4. Mediastinal shadow is narrower than in Figures 4 and 5. Heart size smaller and shape entirely normal. Patient was discharged because of normal chest findings on this roentgenogram.

This case is but one of many similar examples that might be used to illustrate the unnecessarily prolonged hospitalization because of simulated widening of the mediastinal shadow. A point worth mentioning

is that if apparently enlarged mediastinal glands persist unchanged and show no calcium deposition for periods between one and two years, then one should seriously doubt that the mediastinal shadow is due to enlarged caseating tuberculous nodes. In from one to two years, such nodes should either break down or shrink and show evidences of calcification.

Case II (Fig. 7 and 8). M. T., colored male, aged five, was admitted on January 2, 1940, because of the discovery of a positive Mantoux reaction by a local physician and a roentgenogram of the chest made by the Board of Health which was interpreted as showing mediastinal tuberculosis. The contact in this case was the grandmother.

On admission, examination showed a well developed and somewhat emaciated five year old colored male. The heart and lungs were essentially negative except for some diminished breath sounds in left axilla. The weight was 34½ lb. and blood chemistry, urine, blood count and Wassermann reaction negative. The erythrocyte sedimentation rate was 13 mm. per hour, and sputa and gastric contents negative for tubercle bacilli.

Course. Patient began to gain weight soon after admission and physical findings remained essentially negative. Admission roentgenogram showed some thickening of the left pleura which cleared in two months, and widening of the superior mediastinal shadow, especially to the right. Weight gain continued and general condition improved, and patient remained afebrile, with exception of a short period during which a Vincent's infection of the mouth occurred. In spite of the negative physical and laboratory findings, the roentgenographic finding of widened mediastinum persisted (Fig. 7) and patient was therefore kept in the hospital until February, 1941, when an upright roentgenogram was taken (Fig. 8). This showed a striking change of the mediastinal shadow to normal and, as a result, patient was discharged.

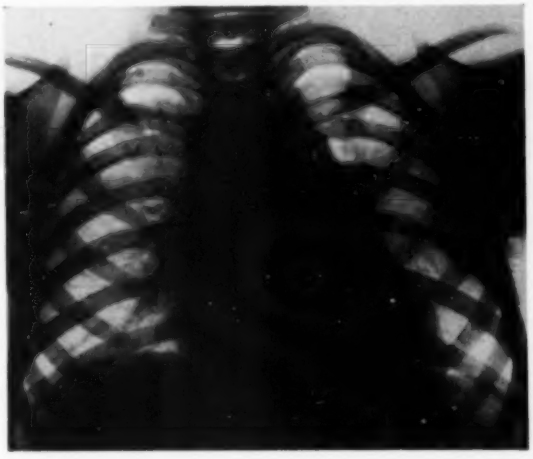

Fig. 7. Case II. Expiratory posteroanterior horizontal roentgenogram (April 15, 1941). Note wide superior mediastinal shadow (more striking in larger original roentgenogram).

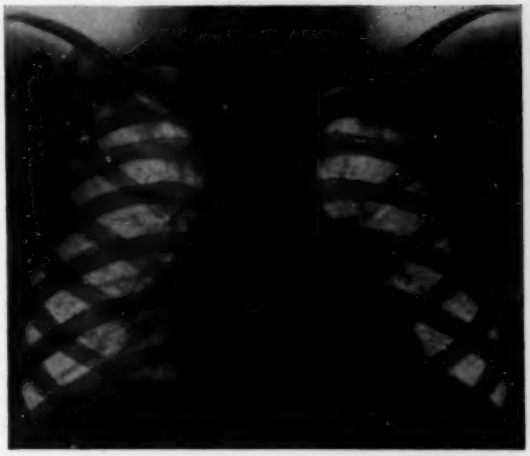

Fig. 8. Case II. Expiratory posteroanterior upright roentgenogram, taken at the same time as Figure 7. The mediastinum, heart and lungs are normal. Patient was discharged on the basis of this roentgenogram.

Comment. Here, too, a patient was hospitalized for one year longer than necessary because the roentgenogram showed apparent widening of the mediastinum. It must be borne in mind that the change between Figure 7 and Figure 8 is much more striking in the larger original roentgenograms than in the smaller reproductions. This applies to all other illustrations shown.

Case III (Fig. 9, 10 and 11). J. O., colored male, aged three, was admitted to Metropolitan Hospital in May, 1937, because of routine Board of Health check-up, and was transferred to Sea View Hospital on February 4, 1939. At Metropolitan Hospital, he was found to have enlarged hilar nodes. On admission to Sea View Hospital, examination showed a well developed,

FIG. 9. Case III. Admission roentgenogram (November 15, 1939) reveals apparent wide mediastinum and large heart. Taken in supine position.

well nourished three year old colored male. There was slight enlargement of the cervical and inguinal nodes. The Mantoux reaction was positive. There was slight beading of the ribs and flaring of the ribs and wrists. The heart and lungs were negative. The abdomen was negative. The tonsils were hypertrophied and cryptic.

Laboratory Data. Blood count, blood chemistry, Wassermann reaction and urinalysis were normal. Gastric findings and feces negative for tubercle bacilli, erythrocyte sedimentation rate was 6 mm. per hour, temperature 100.5° F., weight 32 lb. The admission roentgenogram (Fig. 9) was interpreted as showing marked widening of the mediastinal shadow, due to tuberculous adenopathy.

The patient's course was uneventful. He remained afebrile, gastric findings were always negative for tubercle bacilli, and he might have been discharged except for roentgen findings of widened mediastinum. An upright roentgenogram on March 30, 1941 (Fig. 11) showed mediastinum of normal width and patient was discharged. A horizontal roentgenogram (Fig. 10) made at the same time again revealed apparent widening of the mediastinal shadow.

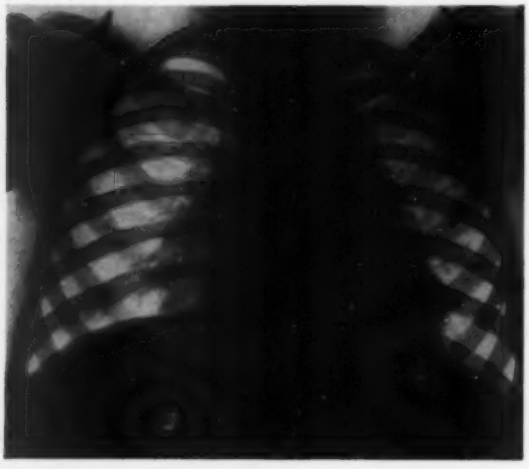

FIG. 10. Case III. Supine roentgenogram taken sixteen months later (March 30, 1941) shows persistence of wide mediastinal shadow. On basis of this roentgenogram patient would not have been discharged.

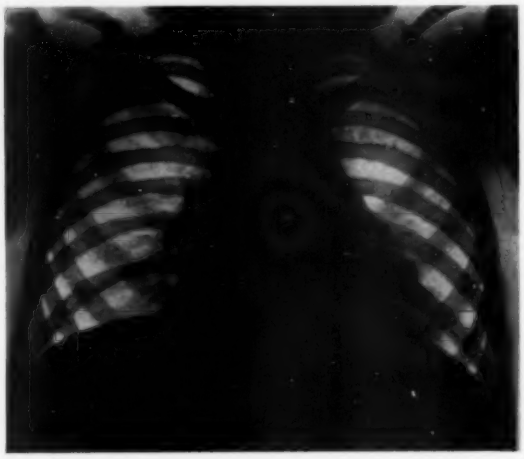

FIG. 11. Case III. Posteroanterior upright roentgenogram made at same time as Figure 10 reveals normal mediastinum and no enlarged nodes. Patient discharged as result of this roentgenogram.

Comment. The admission roentgenogram would probably have shown a normal mediastinum if it had been taken in the upright position. Two years later (Fig. 10) the roentgenogram taken in the supine position still shows apparent marked widening of the mediastinum and enlargement of the cardiac silhouette, though this disappears in the upright roentgenogram (Fig. 11). The lack of calcification in the hilar or paratracheal nodes on his final roentgenograms (four years after original hospitalization) throws doubt on whether caseous enlarged hilar nodes were originally present.

Fig. 12. Case IV. Anteroposterior expiratory horizontal roentgenogram (April 25, 1941) reveals widest mediastinal and heart shadow and poorest aeration of lungs.

Fig. 14. Case IV. Anteroposterior expiratory upright film, taken at same time shows heart and mediastinal shadows to be much narrower than Figures 12 and 13.

Case IV (Fig. 12, 13, 14 and 15). C. W., colored male, admitted on October 29, 1940, at the age of eleven years because of loss of weight, low grade fever and roentgen findings of widened mediastinum and positive tuberculin test. The contact was found to be a boarder. Father, mother and brother all were found to be well. Past history revealed pertussis at nine months, varicella at three months, mumps at two years, pneumonia at one year and tonsillectomy at age of three years. Examination on admission revealed heart negative, lungs showing dullness in both apices posteriorly and diminished breath sounds in upper half of right chest posteriorly. The remainder of physical examination was negative. Laboratory findings included blood count, urinalysis, Wassermann test, blood chemistry—all normal. Feces and gastric findings negative for tubercle bacilli. Erythrocyte sedimentation rate 31 mm. per hour, temperature below 100° F., and roentgenogram of chest showed marked hilar adenopathy. During stay

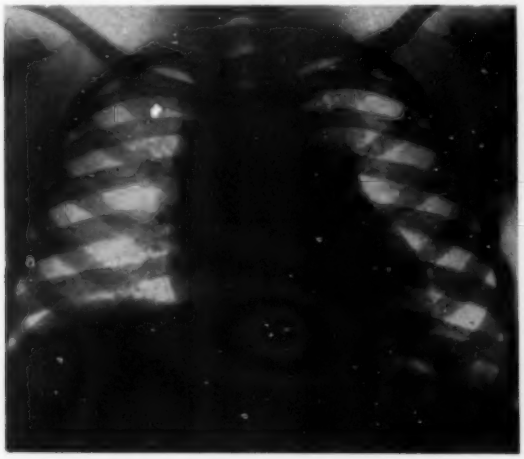

Fig. 13. Case IV. Posteroanterior expiratory horizontal roentgenogram, taken at the same time as Figure 12. Mediastinal and heart shadows are slightly narrower, but still strikingly enlarged and misleading.

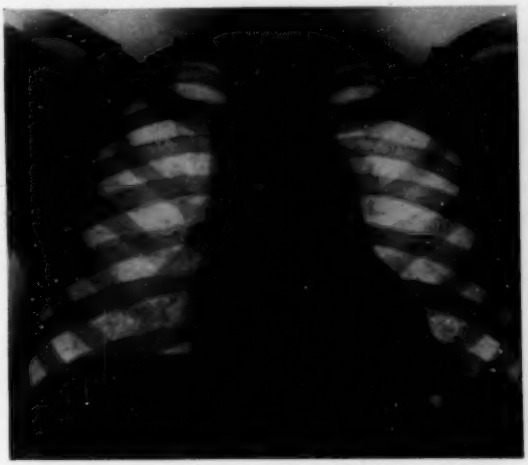

Fig. 15. Case IV. Posteroanterior expiratory upright roentgenogram (April 25, 1941) shows narrowest and most normal appearance of heart and mediastinum. Slight enlargement of the paratracheal nodes is still evident bilaterally.

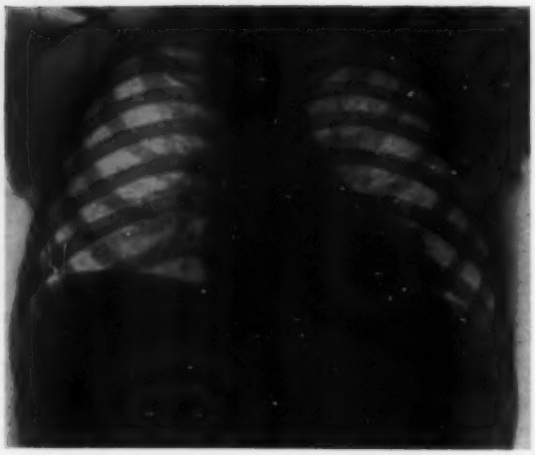

FIG. 16. Case v. Admission roentgenogram (January 30, 1940) was made in the upright position because patient was older and cooperative. Mediastinal shadow is narrow and normal, but heart shows wide transverse diameter because diaphragms are high (expiration) and push heart up.

in hospital, the temperature did not rise above 100° F., and patient was clinically negative. The erythrocyte sedimentation rate fell to 6 mm. per hour on January 29, 1941. Patient was discharged in April, 1941.

Comment. Just before discharge, four roentgenograms were taken in different positions (Fig. 12, 13, 14 and 15) which illustrate striking changes that may be produced due to roentgenographic technique. In Figure 15, though the mediastinal width is almost half that of Figure 12, it is still evident that slight enlargement of the paratracheal nodes is present. The upright technique will often reveal enlarged hilar or paratracheal nodes which in the supine position are obscured by false widening of the mediastinal shadow.

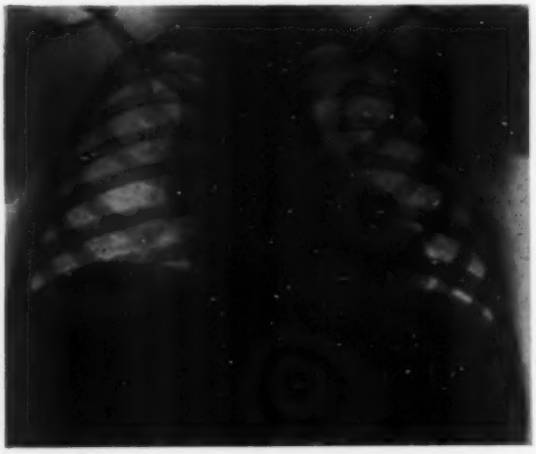

FIG. 17. Case v. Expiratory supine roentgenogram (October 15, 1940) shows apparent widening of the mediastinal shadow and marked enlargement of right paratracheal and bronchopulmonary nodes. Actually shadow is caused by elevation of diaphragms due to expiration, horizontal position plus slight rotation.

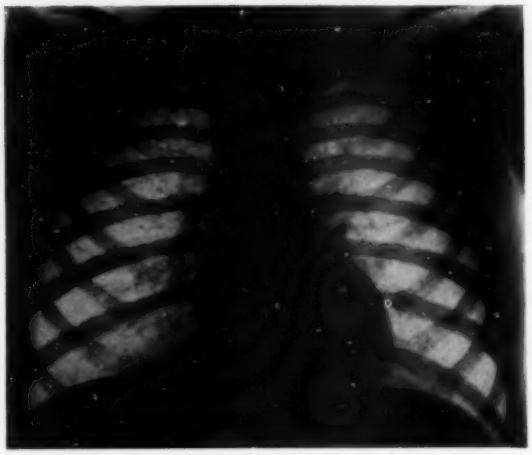

FIG. 18. Case v. Roentgenogram taken less than two months later (January 10, 1941) in posteroanterior upright inspiratory position, shows striking reversion of mediastinum and heart shadow to normal. Note greatly improved aeration of lungs.

CASE V (Fig. 16, 17 and 18). D. P., colored female, aged four, admitted to Sea View Hospital on January 29, 1940. The past history is irrelevant. The contact is not known. The patient was originally admitted to Harlem Hospital in December, 1939, for unexplained elevation of temperature, and while on the ward, she developed a large mass in the right axilla which was aspirated and found to contain tubercle bacilli. The child was then transferred to Sea View Hospital where physical examination on admission was essentially negative, except for enlargement of the cervical nodes to a little more than twice their normal size, and a mass half the size of a lemon in the right axilla. The blood chemistry, blood count and Wassermann test were normal. Hemoglobin was 66 per cent. Urine, feces and gastric examinations were negative for tubercle bacilli. The erythrocyte

sedimentation rate was 20 mm. per hour. The patch test was positive.

Admission roentgenogram of the chest (Fig. 16) revealed slightly increased prominence of the right hilar shadow and destruction of the posterior axillary segment of the ninth right rib. The patient's course was uneventful. The mass was aspirated once and then promptly healed. The patient was afebrile, except for an occasional rise to 100° F. The erythrocyte sedimentation rate returned to normal and the patient's condition continued to be satisfactory until October, 1940, when a chest roentgenogram (Fig. 17), taken in the horizontal position, showed marked increase in the width of the superior mediastinal shadow. The physical examination, sedimentation rate and temperature were all normal at this time. Another roentgenogram of the chest taken in the upright position (Fig. 18) again revealed a normal mediastinum and the patient was discharged from the hospital.

Comment. This patient was not admitted for either pulmonary or mediastinal tuberculosis and never had any clinical evidence of such. Yet Figure 17 might well be interpreted as showing enlarged bronchopulmonary and paratracheal nodes on the right. This case is especially interesting since Figure 16 (the admission roentgenogram) was an upright roentgenogram and shows a normal mediastinum, whereas Figure 17 was made in the horizontal position with striking alteration of the heart and mediastinal appearance. Figure 18, again made in the upright position, reveals a very normal heart and mediastinum. Also note how much better and more normal the appearance of the lungs are in the inspiratory upright roentgenogram (Fig. 18) than in the expiratory horizontal roentgenogram (Fig. 17).

Fig. 19. Case VI. Roentgenogram taken in the posteroanterior horizontal position during forced expiration (child crying).

Fig. 20. Case VI. Roentgenogram taken five minutes after Figure 19, in the identical position but during inspiration.

Case VI (Fig. 19 and 20). P. D., aged three months, was admitted solely because mother was admitted as a patient with pulmonary tuberculosis. The infant was kept at the hospital for only three months until suitable home conditions could be arranged. At no time was there any evidence of tuberculosis. The patch test and Mantoux reaction were negative and roentgenogram of the chest normal. The gastric findings were negative for tubercle bacilli. On admission, patient was markedly dehydrated and underweight but responded promptly to routine care.

Comment. Figure 19 was taken at expiration in the horizontal posteroanterior position while the child was crying. This illustrates the marked changes in the aeration of the lungs and width of the mediastinal shadow and shape of the heart, as a result of increased intrathoracic pressure (crying). An erroneous diagnosis of enlarged thymus might be made from this roentgenogram.

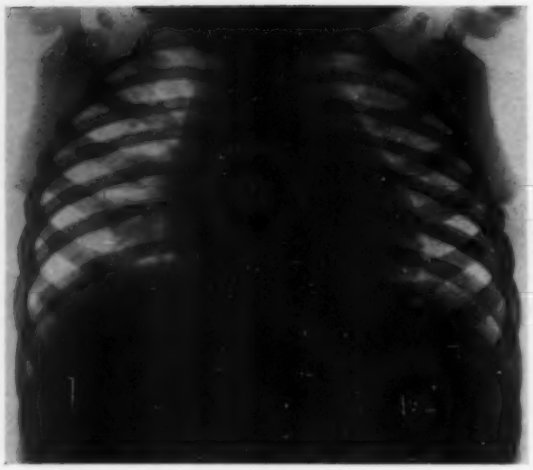

FIG. 21. Case VII. Anteroposterior expiratory roentgenogram in horizontal position.

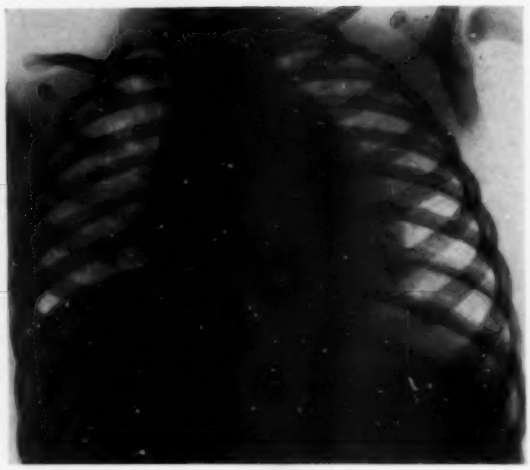

FIG. 23. Case VII. Posteroanterior expiratory roentgenogram in horizontal position.

FIG. 21–28. Case VII. These roentgenograms were all taken at the same time and illustrate the changes in the mediastinal and heart shadows due to variations in position and phase of respiration.

Figure 20 was made in exactly the same posteroanterior horizontal position but was taken during inspiration. The lung fields are much better aerated and the mediastinal and heart shadows much more normal in appearance, thus illustrating the changes due to inspiration and expiration alone.

CASE VII (Fig. 21–28). H. B., a newborn normal infant, whose mother was a tuberculous patient at Sea View Hospital and who was delivered by cesarean section on June 14, 1940. The child was immediately removed from the mother and remained in the hospital for two months, during which time arrangements were made for its care, after which it was discharged. The infant weighed 7½ lb. at birth and remained well during its two months' stay in the institution. The tuberculin test was normal though the mediastinal shadow was thought to be widened. The child was brought back to the hospital on March 19, 1941, for a follow-up examination. The tuberculin test was still negative and a series of eight roentgenograms were taken in various positions and phases of respiration as part of this study.

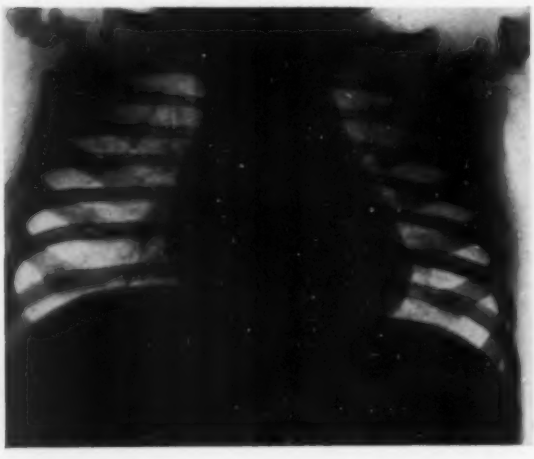

FIG. 22. Case VII. Anteroposterior inspiratory roentgenogram in horizontal position.

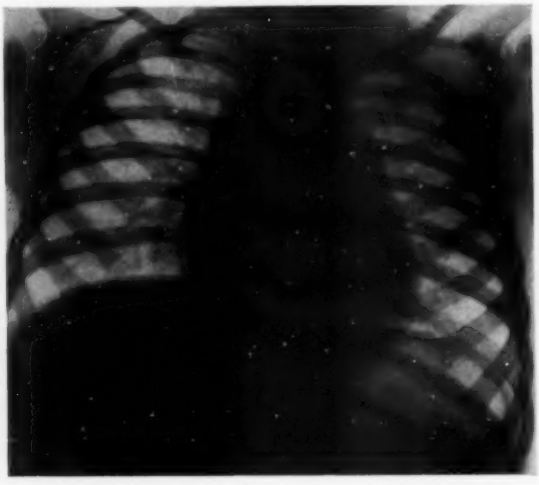

FIG. 24. Case VII. Posteroanterior inspiratory roentgenogram in horizontal position.

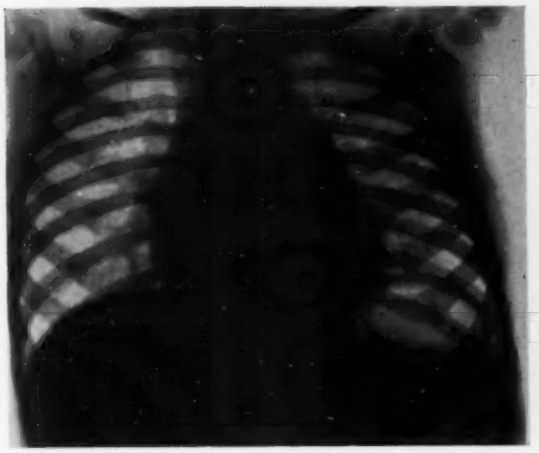

Fig. 25. Case VII. Anteroposterior expiratory roentgenogram in upright position.

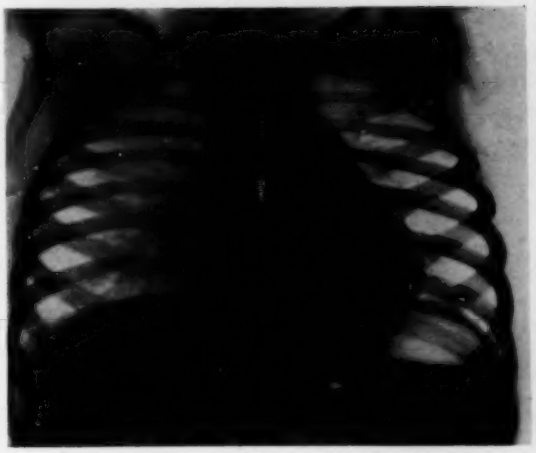

Fig. 27. Case VII. Posteroanterior expiratory roentgenogram in upright position.

Comment. This case illustrates the striking changes that may be produced by variations in roentgenographic technique. All eight roentgenograms were taken within half an hour. Figure 28 shows normal heart and mediastinum. Compare this with Figure 21 in which the heart shadow is enlarged and the mediastinum greatly widened. Figure 23, which was taken at expiration in the prone position, reveals congestion and marked diminution in aeration of the right lower lobe. A faulty diagnosis of bronchopneumonia in the right lower lobe might have been made on the basis of this roentgenogram. This can be appreciated more in the original roentgenogram than in the smaller reproduction here. The changing size and configuration of the heart shadow on all eight roentgenograms illustrates the errors inherent in measuring and judging heart size and shape, unless all roentgenograms being compared are made under identical conditions, i.e., same phase of cardiac cycle, same phase of respiration, same upright or horizontal anteroposterior or posteroanterior position.

This case also illustrates the fact that upright roentgenography of the chest is

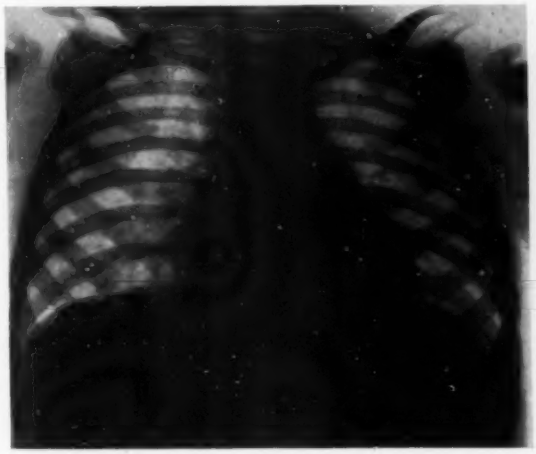

Fig. 26. Case VII. Anteroposterior inspiratory roentgenogram in upright position.

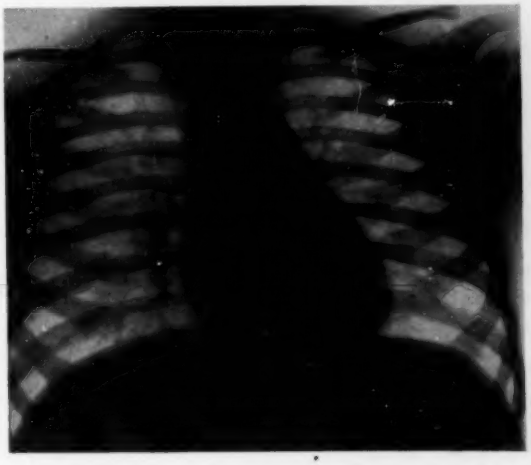

Fig. 28. Case VII. Posteroanterior inspiratory roentgenogram in upright position.

perfectly feasible even in the newborn. It is apparent that the mediastinal shadow is narrower and more normal in the roentgenograms taken in the posteroanterior position than those made in the anteroposterior position; narrower and more normal in the upright than in the horizontal position; narrower and more normal on roentgenograms taken in inspiration than on those made in expiration.

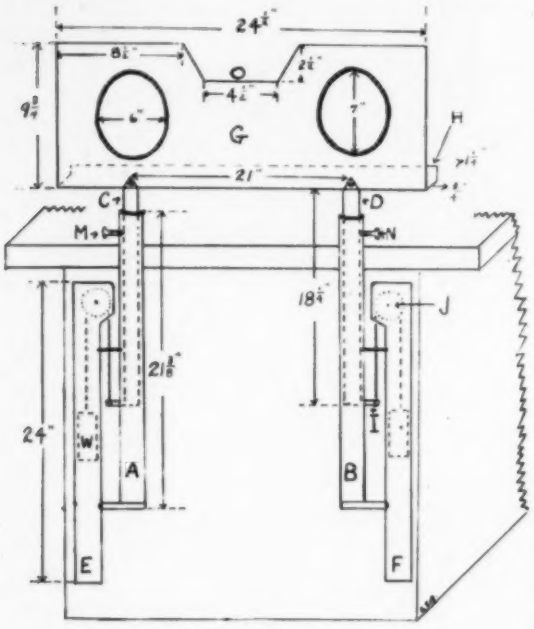

FIG. 29. Line drawing of apparatus.

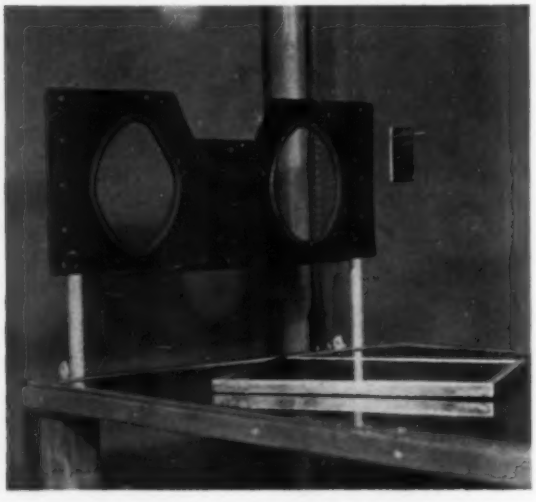

FIG. 30. Photograph of apparatus for upright roentgenography of the chest.

DESCRIPTION OF APPARATUS

The apparatus used to facilitate upright roentgenography is illustrated in Figure 29. It consists of a metal plate (*G*) 24½ in. wide by 9¾ in. high, in which there are two large oval apertures, each 6 by 7 in. in diameter, one on each side to accommodate the arms of the patient, which project through the armholes and are held by the nurse or attendant (see Fig. 31). The holes are lined by sponge rubber to avoid scratching the patient. The lower edge of the metal plate is bent so as to form a right angle shallow trough (*H*) upon which the cassette rests. The metal plate *G* is thus converted into a simple and inexpensive cassette holder. To the lower edge of the cassette holder, near either end, are riveted two round bars of ½ in. brass pipe (*C* and *D*) which, in turn, telescope within two brass pipes of ¾ in. diameter (*A* and *B*). To the lower ends of pipes *C* and *D* there is welded at right angles a small metal rod (*I*) to which is attached a light wire cable which passes around pulley (*J*) and is attached to counterweight (*W*). The counterweight moves within a brass pipe (*E*), attached to the end of the roentgenographic table and which is secured to pipes *A* and *B* by means of weld (*K*). Pipes *A* and *B* are also secured

FIG. 31. Photograph of apparatus showing patient, cassette and attendant in position for upright chest roentgenography.

rigidly to each edge of the end of the roentgenographic table and each pipe has a narrow slit running along its entire length to allow rod *I* to move up and down. At the upper end of pipes *A* and *B*, there is a threaded hole to accommodate thumb screws (*M* and *N*) which, when turned, lock the cassette holder at the desired height. The tray of the cassette holder *G* has a cut-out (*O*) to accommodate the chin. When the apparatus is not in use, the thumb screws are loosened and the entire cassette holder and attached bars *A* and *B* can be very easily lifted out and removed from the apparatus. This is a very necessary and desirable feature, since it leaves the end of the roentgenographic table free and unobstructed.

The entire apparatus is secured rigidly to one end of the roentgenographic table and requires only a touch of the finger to move up or down because of the counterweight and pulley arrangement. The patient sits on the edge of the table (see Fig. 31), and arms are passed through the armholes and held by the nurse. This bring the chest of the patient against the cassette and the roentgen tube is simply turned to focus the central ray toward the patient. In this way, posteroanterior upright roentgenograms can be secured with equal facility at 6 ft. distance as at 30 in., which is a great advantage when studying the heart size and shape in children. Even newborn infants have been roentgenographed with this apparatus with less difficulty than in the conventional horizontal position and the resulting roentgenograms have been superior in all respects. Lateral and oblique views can be secured as readily as posteroanterior views by simply turning the sitting child to the desired angle. Teleroentgenograms for heart study are secured with great ease by simply moving the rail mounted tubestand back to 6 ft. distance.

The device has been found of great value in roentgenography of adults as well as infants since it happens not infrequently that a sick adult is able to sit up with support but is unable to stand. Thus, by using this apparatus, excellent 6 ft. roentgenograms can be secured in place of the generally unsatisfactory 36 in. distance horizontal films. This is particularly advantageous in roentgenography of decompensated cardiac patients. The apparatus is very substantial, is extremely simple in operation, very inexpensive, can be easily home made, and is suitable for attachment to any table.

It must be emphasized that the nurse or attendant who holds the arms of the patient is thereby exposed to the rays and should always wear a lead apron when the exposure is made.

SUMMARY

The difference in results with upright and horizontal chest roentgenography has been compared and analyzed in 25 cases. Ten of these cases were selected for special study to determine the effects of respiratory phase, position (upright or horizontal) and type of projection (anteroposterior or posteroanterior). An explanation is offered for the striking variations that may result from changes in the method of roentgenographic examination, and the importance of the upright position is emphasized. The anatomy of the mediastinum is briefly reviewed.

CONCLUSIONS

1. The horizontal method of chest roentgenography should be replaced by, or augmented by, the upright method. No reliance should be placed on the horizontal method alone.
2. Upright posteroanterior roentgenograms taken at the end of inspiration give the least distorted views of the mediastinum.
3. Cardiac measurements are not completely reliable and comparable by serial study unless the exposures are synchronized with a phase of the cardiac cycle.
4. The diagnosis of "enlarged thymus" is too often erroneous because of mediastinal widening due to technical

factors. Roentgenography of the thymus should include upright posteroanterior and lateral views.

5. Upright posteroanterior views taken at the end of inspiration are most satisfactory.
6. A simple, inexpensive device can be made to provide such views.
7. Bronchopneumonia may, on occasion, be incorrectly read into roentgenograms made in the horizontal position, at the end of expiration. Roentgenograms so taken should be interpreted with caution.

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OIL ASPIRATION PNEUMONIA

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SINCE Laughlen's[8] report of 5 cases of oil aspiration pneumonia, numerous authors have reported either isolated cases or small groups of cases, and, in a few instances, larger series. Most of the cases described were discovered at postmortem examination. Pinkerton[10] found 6 cases in 290 necropsies of infants and children. Bromer and Wolman[1] reported 27 cases in children. Of these, 8 were diagnosed clinically, and 1 of these, as well as the other 19, was confirmed as oil aspiration pneumonia on postmortem study. Goodwin[6] found 25 cases in children during a ten year period at the Harriet Lane House. Of these, only 3 were diagnosed clinically. Cannon[3] found 39 cases in 2,000 consecutive necropsies, of which 12 were in infants and children, and 27 in adults. Freiman, Engelberg and Merrit[5] reported a series of 47 cases of oil aspiration pneumonia. Of these, 7 were diagnosed clinically, and 40 were found in 3,500 consecutive autopsies over a period of ten years.

The number of cases of oil aspiration pneumonia in the literature is not very large. Undoubtedly many cases have been recognized but not reported. It is our belief that the incidence of this disease is much greater than one would estimate from the number of cases reported in the literature. Because of this, we wish to report our experiences.

ETIOLOGY AND PATHOLOGY

The etiology and pathology of oil aspiration pneumonia have been well established and described by Pinkerton,[11] Cannon,[2] Cannon and Walsh,[4] Laughlen[8] and Ikeda.[7] The causative agent is a lipoid, or lipid substance, entering the lungs in one of three ways: (1) through the mouth; (2) instilled into the nose as drops; (3) through a tracheotomy opening.

Responsible lipoids may be divided into three groups:

1. *Animal oils:* halibut liver and cod liver oils, milk and egg yolk.
2. *Vegetable oils:* castor oil, olive oil and wheat germ oil.
3. *Mineral oils:* liquid petrolatum.

The predisposing conditions favoring the development of oil aspiration pneumonia are chiefly those which interfere with the normal swallowing act. They are:

1. Perforated palate.
2. Forceful feeding in crying and debilitated children.
3. Neurologic conditions at any age causing dysphagia, such as multiple sclerosis, cerebrovascular disease, brain tumors, etc.
4. All debilitating diseases compelling the patients to become bedridden, such as the arthritides, Little's disease, neurological conditions, etc. Aside from the fact that these patients have difficulty in swallowing, they become constipated. To alleviate the constipation, mineral oil is administered.
5. Upper respiratory infections—treated by intranasal administration of oily medications.

The pathogenesis and pathologic pictures have been established and described by Cannon. The fundamental pulmonary lesion is essentially a low grade interstitial proliferative type of inflammation with a foreign body reaction. The lesion has been described as showing numerous endotheliocytes in the involved lung area or areas with giant cell formation of the foreign body

* Resident, July 1, 1940, to June 30, 1941.

type. The lipoid substance is both intra- and extracellular, the latter being in the alveolar spaces. The epithelial lining of the alveolar spaces assumes a cuboidal form. The mononuclear endotheliocytes contain oil droplets. Many of the cells have a signet ring appearance with the oil occupying the cytoplasmic portions of the cells. The nucleus is eccentrically placed. There is some round cell infiltration. A superimposed bronchopneumonia may accompany the oil aspiration pneumonia. The lymphatics become permeated with oil-laden cells. Some of the oil may be carried to the hilar lymph nodes. Cases have been reported by Pinkerton and Moragues[12] and Young, Applebaum and Wasserman,[14] where the oil has been found in distant organs such as the liver and spleen. The more frequent locations of oil aspiration are in the lower lobes, most commonly in the right lower lobe. Any or all lobes may be involved.

The severity of the reaction depends upon the type of oil used. The difference in degree of toxicity of the various types of oils has been shown by Ikeda, and Pinkerton and Cannon, and their findings are generally in agreement.

Vegetable oils, as a group, are least irritating, least toxic, producing a slight degree of proliferative reaction with invasion of macrophages. The pure vegetables oils, such as olive oil, cotton seed oil and oil of sesame lie free in the alveoli, produce no symptoms, and may be largely removed by coughing and expectoration. Chaulmoogra, a vegetable oil, has been found to be very damaging because of its high fatty acid content.

Animal oils, as a group, are the most toxic. This is due to their high fatty acid value and the ease with which they undergo hydrolysis. The more unsaturated the oil, the easier it hydrolizes, the greater the reaction (Paterson)[9]. For this reason the most toxic of the animal oils is cod liver oil.

Unlike animal and vegetable oils, liquid petrolatum is chemically inert and acts purely as a foreign body in the pulmonary parenchyma. It is eliminated partly by expectoration and partly removed through the lymphatics by wandering cells. According to Ikeda, the presence of mineral oil in the lung causes local irritation which results in a low grade proliferative inflammation analogous to a foreign body reaction. Medicinal agents such as menthol, thymol and ephedrine are responsible for an acute diffuse exudative inflammation because of the chemical irritation to the lungs. The result is a superimposed acute inflammation on a foreign body reaction. The former often subsides spontaneously in the absence of bacterial invasion, while the petroleum continues to act as a foreign body.

Wolman and Bayard[13] described a characteristic fluorescence to the consolidations of oil aspiration pneumonia in human lungs when examined in a dark room under ultraviolet light. The areas of consolidation were visible as pale yellow, gray, white or greenish fluorescence. They claim that the various lipoid substances have a specific fluorescent color and that the pathologic diagnosis should state specifically the causative agent by diagnosing the lesion as either mineral oil pneumonia, cod liver oil pneumonia, milk aspiration pneumonia, etc., instead of the general term oil aspiration pneumonia. In their experimental work they were unable to demonstrate lipid deposits and signs of chronicity when milk was the causative agent. They recommend that milk aspiration pneumonia be separated from the term oil aspiration pneumonia.

The lesions of oil aspiration pneumonia have been classified by various authors. Cannon and Walsh described the lesion as an exudative or proliferative inflammation, depending upon the amount and kind of lipoid agent used. The lesion may be diffuse or local. The acute state is exudative. It is caused by the accumulation of lipophages in the alveoli, often with secondary infection. The later stage is characterized by interstitial fibrosis.

Pinkerton divided the oil aspiration pneumonia due to liquid petrolatum into two types very similar to the division used

by Cannon: (1) acute pneumonic process characterized by the accumulation of macrophages and round cells; (2) the second type is characterized by marked fibrosis with multiple nodules in the lungs. These nodules are composed of large globules of liquid petrolatum imbedded in dense fibrous tissue and are comparable to the so-called paraffinomas.

Ikeda[7] similarly described two types, the infantile and adult. In the infantile type the etiologic agents are cod liver oil, milk and mineral oil. It is essentially an interstitial proliferative inflammation not infrequently combined with an exudative pneumonia. The exudative pneumonia is due either to the irritation of the oil or to bacterial invasion. The adult type is the result of the administration of oil in large amounts by either the nasal or oral routes over a prolonged period of time. Liquid petrolatum and its numerous medicated preparations are the responsible agents. He described the adult type as being essentially a paraffinoma in its various stages of development. These stages extend from early non-suppurative proliferative interstitial pneumonitis to a chronic granulomatous foreign body reaction with widespread fibrosis and tumefaction. The infantile type of oil aspiration pneumonia may be regarded as representing the initial stage of the adult type. The fundamental process is essentially that of a foreign body reaction to the presence of an insoluble oil and consists primarily of (1) the massive infiltration of macrophages; (2) the proliferation of stroma cells, and (3) the appearance of foreign body giant cells.

According to the pathologic findings as described by various authors, one may divide the lesions into three types:

(1) Diffuse acute—representing the first stage and corresponding to the infantile type of Ikeda.

(2) Diffuse chronic—representing the intermediate stage, and consisting essentially of a proliferative fibrosis. In this stage acute bronchopneumonia may be superimposed.

(3) Chronic localized—representing the tumor-like paraffinomas.

CLINICAL ASPECTS

The clinical signs and symptoms are indefinite and not at all characteristic. The most common symptom is cough, which may be either productive or non-productive. There may be shortness of breath. The temperature usually remains normal unless there is a superimposed bronchopneumonia. There may be a concomitant infection other than in the pulmonary system, such as infected decubitus ulcers, or infections in the urinary tracts. In these cases, a low grade temperature is present. Pain in the chest is rarely a complaint. The physical signs are even less constant. One may hear increased voice and breath sounds, dry and moist râles, particularly at the bases. The patient may be asymptomatic, and show definite roentgen findings.

The roentgen findings have been described by Bromer and Wolman.[1] They classify the lesions as mild, moderate and severe. This classification is not dependent upon a time factor following aspiration or upon the kind of oil used. In their series the extent of involvement depended upon the quantity of oil in the lung, regardless of whether it was aspirated in a single large dose or in repeated small doses. Patients having only a mild involvement showed an increase in the size and density of the lung markings and hilar shadows. Scattered small areas of increased density may be present about the hilar shadows. These findings are pronounced in the group with moderate involvement. In the severe cases the perihilar shadows spread out toward the periphery of the lungs, usually leaving a narrow clear zone adjacent to the axillary chest wall. A true lobar pneumonia is not observed unless a non-lipoid pneumonia is superimposed. A paraffinoma is recognized in the roentgenogram as a well defined localized area of absent aeration which may be difficult or impossible to differentiate from a pulmonary neoplasm.

With oil aspiration pneumonia there is

FIG. 1. Case I. G. K., male, aged fifty-seven. Cerebellar pontine angle tumor. Daily intake of mineral oil for more than one year, until one year ago. Persistent changes of coalescent bronchopneumonia in the right lower lobe for more than five months.

little or no change in the appearance of the lung fields on serial roentgenograms. This, together with the history of oil administration and difficulty in swallowing, should establish the diagnosis.

DISCUSSION OF CASES

Twenty cases of oil aspiration pneumonia were diagnosed clinically within a period of seven months at Welfare Hospital for Chronic Diseases.* Of these, 5 were sub-

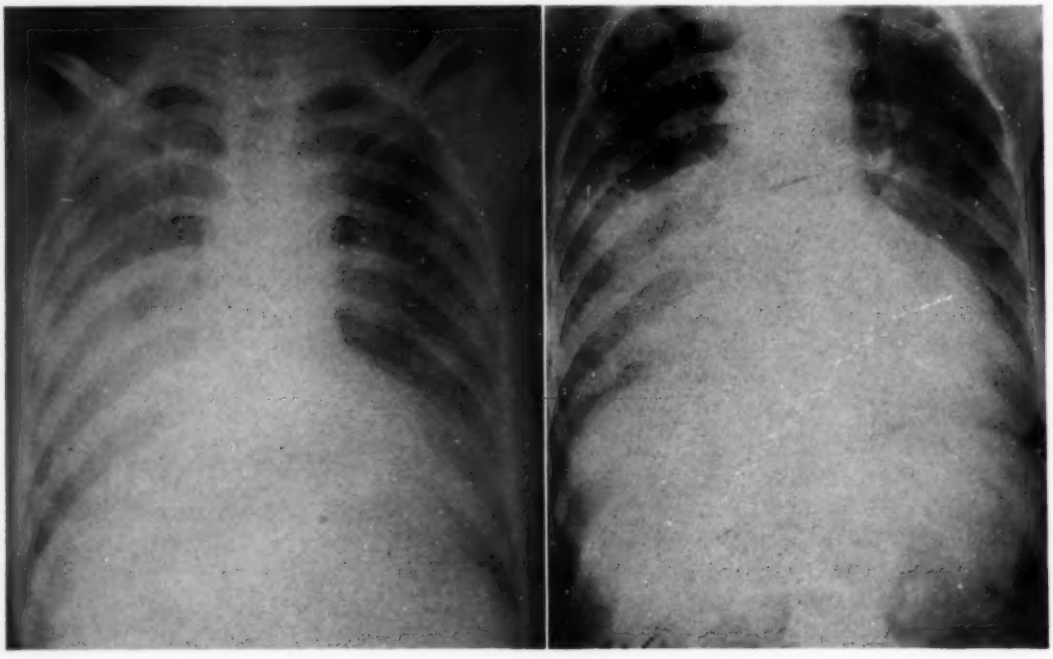

FIG. 2. Case II. M. W., female, aged fifty-one. Multiple cerebral vascular accidents with pseudobulbar palsy syndrome and aphasia. Debilitated for many years. Difficulty in swallowing. Received 25 ounces of mineral oil for three months prior to admission. Diffuse parenchymal changes persistent for more than three months. Postmortem confirmed findings of oil aspiration pneumonia.

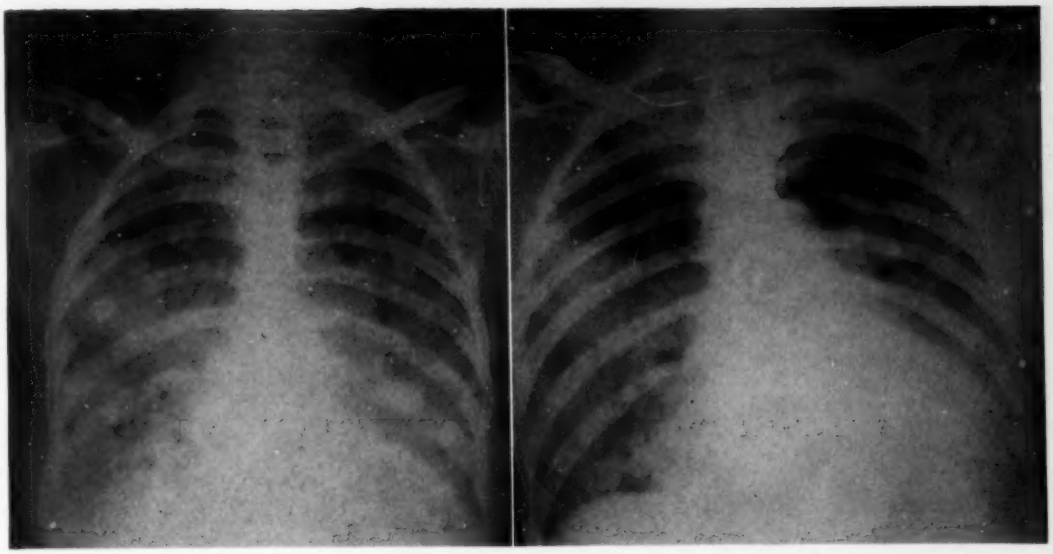

Fig. 3. Case III. I. C., female, aged forty-three. Hemiplegic for five years. Bedridden. Diffuse bilateral parenchymal changes for more than fourteen months. Postmortem confirmed findings of oil aspiration pneumonia.

sequently proved at necropsy. The apparent high incidence is attributed to the fact that most of our patients are aged and bedridden.

Because of the protracted character of a lesion in 2 cases diagnosed as bronchopneumonia, our investigation was started which ultimately led to the diagnosis of oil aspiration pneumonia. A review of our so-called protracted bronchopneumonias revealed several patients with oil aspiration pneumonia.

Our interest led us to investigate the

* Welfare Hospital was opened to patients in July, 1939.

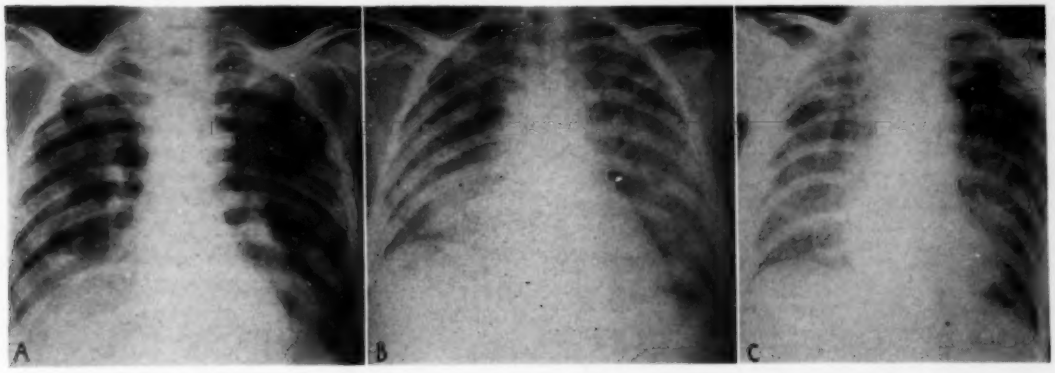

Fig. 4. Cases IV, V and VI.

A, Case IV. D. C., male, aged forty-six. Amyotrophic lateral sclerosis. Difficulty in swallowing. Bedridden for one year. Received 37 ounces of wheat germ oil, 2 ounces of castor oil during his hospital stay. Diffuse coalescent bronchopneumonia due to oil aspiration pneumonia. Postmortem confirmed findings of oil aspiration pneumonia and confluent lobular pneumonia.

B, Case V. L. Mc., female, aged forty-three. Multiple sclerosis. Dysphagic and bedridden for many years. Mineral oil intake for more than one year. Diffuse coalescent bronchopneumonia due to oil aspiration pneumonia.

C, Case VI. E. K., female, aged sixty-nine. Debilitated and bedridden. Dysphagic and regurgitated food. Daily intake of oil over a long period of time. Diffuse parenchymal changes due to oil aspiration pneumonia. Postmortem confirmed findings of oil aspiration pneumonia.

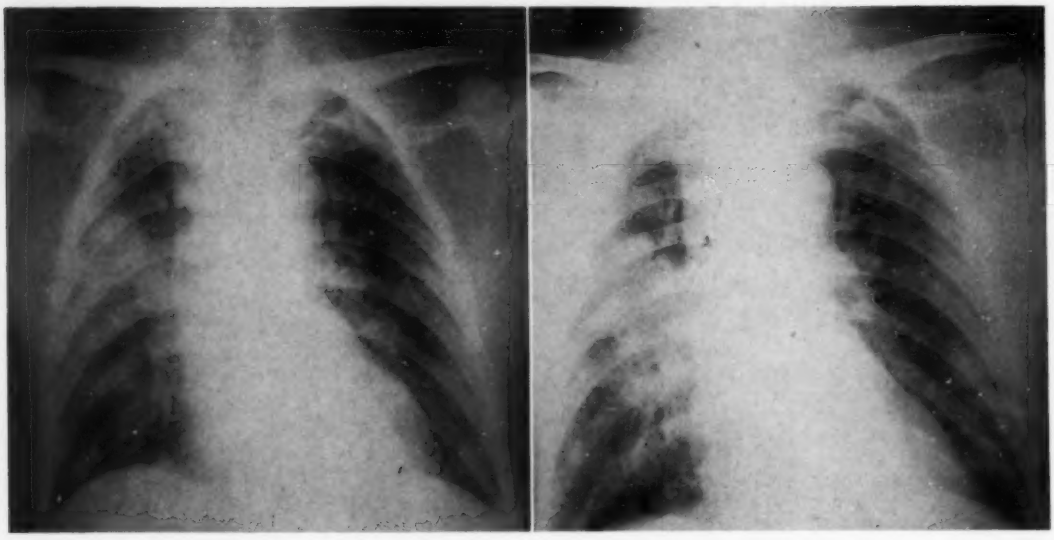

FIG. 5. Case VII. T. R., male, aged sixty-five. Rheumatoid arthritis. Bedridden several years. Difficulty in swallowing. Daily intake of mineral oil. Persistent lesion in the basal and axillary portion of the right upper lobe for more than nineteen months.

necropsy records, and we found 13 additional cases in 300 consecutive autopsies in a period of eighteen months. These are not included in this report. Some of these cases might have been diagnosed antemortem had we been thinking of oil aspiration pneumonia.

Among the 20 cases the sexes were equally divided. Their ages ranged from twenty-six to eighty-two years. In all these cases an accompanying disease contributing to the development of oil aspiration pneumonia was present. These patients could be divided into three groups: neuro-

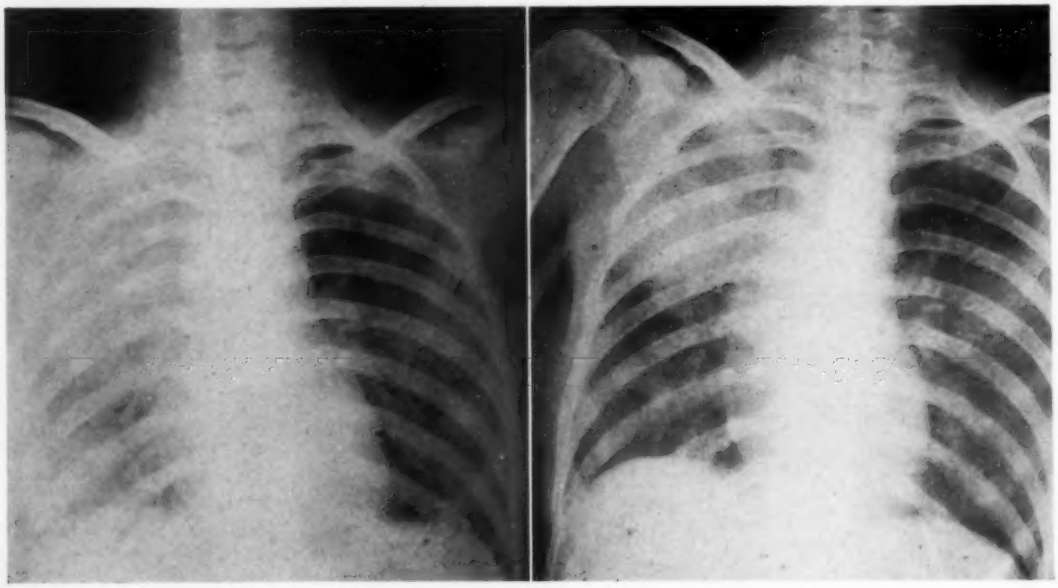

FIG. 6. Case VIII. E. G., female, aged twenty-six. Multiple sclerosis. Dysphagic and bedridden for more than one year; 5 cc. wheat germ oil daily for nineteen months. Persistent coalescent lesion in the right upper lobe for more than twenty-three months.

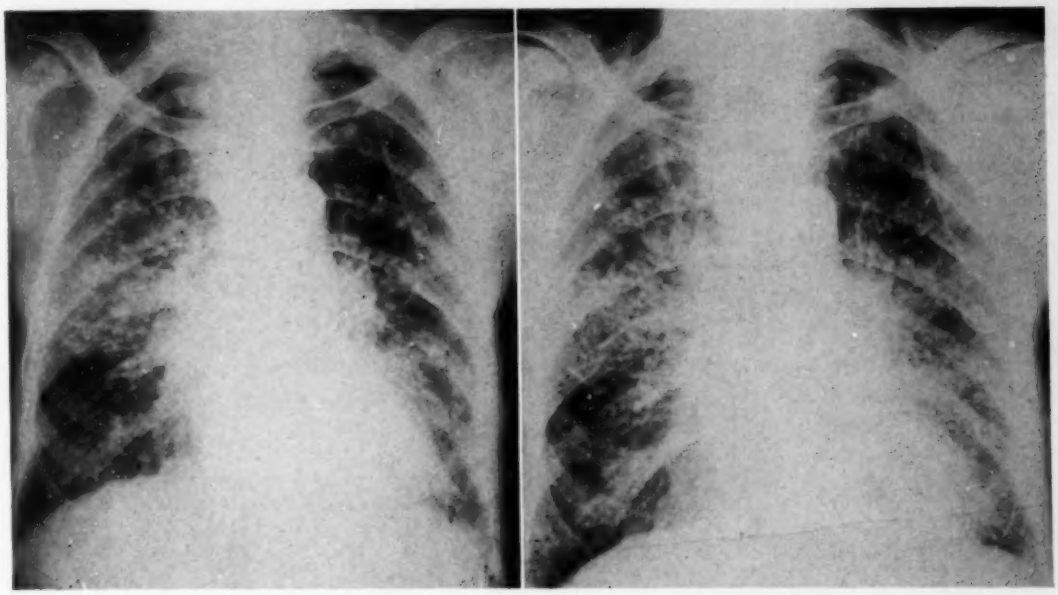

Fig. 7. Case IX. A. E., female, aged eighty-seven. Bedridden for the past seven months. Pulmonary roentgen findings have persisted for more than three months. No history of intake of oil. Clinical investigation leads to the diagnosis of aspiration of milk.

logical, cerebrovascular and arthritics. In the neurologic group there were 6 with multiple sclerosis, 1 spastic pseudosclerosis, 1 Little's disease, and 1 cerebellar syndrome with cerebellar pontine tumor (operated). There were 4 hemiplegics in the cerebrovascular group. In the third group were 7 patients with advanced chronic rheumatoid arthritis. One in this group also had an accompanying Parkinson's syndrome. The younger age group was in the neurological patients. Their ages ranged from twenty-six to fifty-one, with the exception of one aged fifty-seven, with the cerebellar pontine tumor. The rheumatoid arthritics and hemiplegics were of the older age group. The predisposing and contributing factors in the development of oil aspiration pneumonia were the accompanying dysphagia, weakness and debility.

The oil in all of our patients was administered orally. The most common causative agent was liquid petrolatum given for constipation. A positive history of having taken considerable quantities of mineral oil was obtained in 12 cases. The oil intake was usually an ounce, either daily or every second or third day, over a period of from two months to two years. Two cases, obtaining vitamin therapy, received wheat germ oil frequently for a period of one to two months.

In 6 cases, no history could be obtained of receiving any specific oils. In these cases we knew that no oil had been administered at Welfare Hospital. We could not ascertain whether the patients had received oil prior to their admission. Nevertheless, the roentgen examination of the chests revealed changes suggestive of oil aspiration pneumonia. One case was proved on autopsy. In this case no history of oil administration was obtained.

All our patients received considerable quantities of milk daily. This may have been a factor in the production of oil aspiration pneumonia in some of the cases.

It is our opinion that a diagnosis should be considered in dysphagic and debilitated patients; particularly when serial roentgenograms reveal evidences of a protracted bronchopneumonia, even when no history of oil ingestion is obtainable.

The incidence of oil aspiration pneu-

monia is recognized. Because of this, oily medications and the use of liquid petrolatum have been greatly reduced at Welfare Hospital.

In the diagnosis of oil aspiration pneumonia the clinical signs and symptoms may be of little or no value. In some of our cases no signs or symptoms were elicited, while in others a few moist râles at the bases, and dullness were present. A few patients disclosed a low grade fever. A higher temperature usually indicated a superimposed acute bronchopneumonia or some other infection.

The roentgen examinations revealed an increase in the size, number and density of the lung markings, which had a tendency to become confluent. The root shadows were enlarged. Acinous and lobular exudative lesions were present. Some were confluent, forming larger areas of consolidation. The diminution in aeration depended upon the extent of the involvement. The peripheral portions of the lungs were not involved. These were superimposed upon diffuse interstitial changes. The findings were persistent and showed little or no regression. Progression was manifest with continued oil administration. A superimposed bronchopneumonia may be present which may resolve.

The diagnosis of oil aspiration pneumonia should always be considered when on serial studies there are evidences of a protracted bronchopneumonia, in an individual with a history of oil administration and difficulty in swallowing.

The incidence of oil aspiration pneumonia will be reduced if the use of oily medications and liquid petrolatum is kept at a minimum, or discontinued in the aged, bedridden, debilitated, and those suffering with dysphagia.

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ROENTGENOLOGIC CONSIDERATIONS IN THE DIAGNOSIS AND TREATMENT OF DIAPHRAGMATIC HERNIA*

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ROENTGENOLOGY plays an important rôle not only in the recognition of diaphragmatic hernia but also in the determination of the type of treatment to be instituted.

The incidence of diaphragmatic hernia probably is no greater now than it was twenty years ago. At that time the condition was thought to be uncommon and its recognition during the life of the patient affected was rare. That diaphragmatic hernia is recognized more frequently in recent years is indicated by a review of the cases encountered at the Mayo Clinic between the years 1908 and 1941. From 1908 to 1925 inclusive (eighteen years) 30 instances of the condition were recognized clinically, and 14 patients were operated on. From 1926 to September 1, 1941 inclusive (about sixteen years), the condition was diagnosed more than 600 times and I have operated on 295 patients. This study, therefore, shows that twenty times as many diaphragmatic hernias were recognized in the last sixteen years as had been recognized in the previous eighteen years. I believe that the condition is even more common than the present records indicate. I have routinely examined the diaphragm in the course of other abdominal operations and occasionally have found a small hernia that had not been recognized clinically or roentgenologically before operation.

This marked increase in the frequency of the recognition is due primarily to the development of roentgenologic methods of diagnosis. The clinical recognition of diaphragmatic hernia on the basis of subjective symptoms alone is often difficult. The symptoms are complex because of the various structures involved in the hernia and depend on the amount of mechanical interference with the function of the herniated abdominal viscera, on the degree of the impairment of the normal function of the diaphragm and on the amount of increased pressure within the thorax causing impairment of respiration and circulation.

A study of the subjective symptoms in proved cases of diaphragmatic hernia has established a fairly definite clinical syndrome which enables the clinician in some instances to diagnose or at least to suspect the presence of a diaphragmatic hernia, but this clinical syndrome is never pathognomonic and requires collaboration by roentgenologic studies to establish a definite diagnosis before radical treatment should be instituted.

This is particularly true in certain kinds of hernia especially those of the esophageal hiatus type in which the symptoms frequently simulate those of other organic disease of the abdomen and thorax. In these hiatal hernias the stomach is usually the only abdominal viscus involved in the hernia. They are usually progressive sliding types of hernia and the symptoms vary with the degree and type of herniation; as the hernia progresses different clinical diagnoses may be suggested because of the changing symptoms which simulate those of other conditions. In a series of 295 cases which I have treated surgically it was found that an average of three previous erroneous clinical diagnoses had been made before a correct diagnosis had been established. The most common erroneous diagnoses in order of frequency were cholecystitis, cholelithiasis, gastric ulcer, duodenal ulcer, hyperacidity, secondary anemia,

* Presented at the Forty-second Annual Meeting, American Roentgen Ray Society, Cincinnati, Ohio, Sept. 23–26, 1941.

cardiac disease, carcinoma of the cardia, stricture of the esophagus, appendicitis and intestinal obstruction. This is of particular surgical significance because 25 of these patients had been operated on previously for other conditions without relief of symptoms, but they did obtain relief after repair of the hernia.

Limited time will not permit me to go into detail concerning the clinical manifestations or surgical treatment of these hernias as I wish particularly to discuss some of the roentgenologic considerations which are of great assistance in the clinical recognition and surgical treatment of these hernias.

From the standpoint of treatment, diaphragmatic hernia is primarily a mechanical condition and the only treatment which will completely relieve the condition is operative repair of the abnormal opening or defect in the structure of the diaphragm. The indications for surgical treatment and the methods and technique of the surgical procedure depend on the type, situation and size of the defect in the structure of the diaphragmatic muscle; the kind and amount of abdominal viscera involved in the hernia, and whether or not the herniated viscera are enclosed in a hernial sac.

Many problems are associated in establishing an accurate diagnosis and selection of effective treatment to be instituted. These problems are best solved by the close cooperation with personal conferences between the roentgenologist, clinician and surgeon.

Roentgenography is not only of paramount importance in establishing a definite diagnosis of diaphragmatic hernia but it is of equal importance in ruling out other conditions in which the clinical symptoms often simulate those of diaphragmatic hernia, such as diverticulum of the lower end of the esophagus, diverticulum at the cardia of the stomach, cardiospasm, congenital short esophagus, and total or segmental eventration of the left hemidiaphragm. It is also of equal value in determining the type of diaphragmatic hernia which is present, the possible situation and size of the defect in the diaphragm, the amount of impairment of normal function of the defective diaphragm, and in determining the presence of other complicating or associated conditions of the esophagus and stomach such as ulceration, stricture and neoplasm. However, the presence of these lesions requires confirmation by esophagoscopic examination. I believe it is essential that all patients who have diaphragmatic hernia should not only have complete roentgenographic studies but also thorough esophagoscopic examination before surgical intervention. It is important to rule out the presence of any obstructing lesion of the esophagus in any case in which operation for diaphragmatic hernia is contemplated.

Stricture of the lower end of the esophagus is not uncommonly associated with esophageal hiatus types of diaphragmatic hernia; these strictures often result from cicatricial contraction of a traumatic ulcer caused by the hernia. If a stricture is present, it should be treated by dilatation before operation for the hernia. In some instances sufficient relief will be obtained by dilatation of the esophagus so that no surgical treatment is necessary for the hernia. In other instances the esophagus may be shortened so that the hernia cannot be reduced by surgical procedures.

Carcinoma of the lower end of the esophagus and cardiac end of the stomach may be associated with diaphragmatic hernia. This is probably an unrelated condition although it is possible that a carcinomatous change may take place in a traumatic ulcer resulting from the hernia. The presence of this lesion usually can be determined by roentgenologic examination, but if the malignant lesion is small, it may be overlooked because the barium filling the herniated viscera may obscure the defect particularly in the lower part of the esophagus. Malignant lesions in the cardiac end of the stomach may be overlooked because the marked deformity produced by the malposition of the stomach has obliter-

ated the normal outline of the stomach. The presence or absence of these lesions can be best determined by preoperative esophagoscopic examination with removal of tissue for diagnosis. I have operated on 3 patients who have had carcinoma in the lower end of the esophagus and 4 who have had carcinoma of the stomach associated with the hiatal hernia. In 1 case resection of the esophagus was performed and the other 2 cases were inoperable because of metastasis. In 3 of the 4 cases of carcinoma of the stomach, resection of the malignant lesion as well as repair of the hernia was performed and in 1 case the malignant lesion of the stomach was inoperable. It is also important to determine the presence of an obstructing lesion of the pylorus which may require additional surgical procedures at the time of repair of the hernia. I have operated on 2 patients who had obstructing ulcers of the duodenum and 1 who had carcinoma of the pylorus in addition to the hernia.

CLASSIFICATION OF DIAPHRAGMATIC HERNIA

Roentgenography is an important aid in classifying different types of hernia, but it is usually difficult to make a true classification on roentgenologic findings alone.

Much confusion has occurred because there is no standard nomenclature of classification of the different types of diaphragmatic hernia. Various classifications of these hernias have been made which are based on the embryologic and etiologic aspects, pathologic anatomy, the site of the opening in the diaphragm, the presence or absence of a sac, the content of the hernia and other factors. It is difficult or impossible to make most of these classifications clinically; accordingly, many of them are of little practical value.

From a clinical and surgical standpoint, the history of a preceding injury is helpful in establishing the diagnosis and determining the type, urgency and prognosis of the operative treatment. Because of the practical clinical and surgical significance of trauma as an etiologic factor, I have suggested that diaphragmatic hernia be classified into two main groups: nontraumatic and traumatic. I have subdivided these two groups according to the various types.

Nontraumatic Hernia. A nontraumatic diaphragmatic hernia may be congenital or acquired. If it is congenital, the hernia is attributable to embryologic deficiency and usually does not have a hernial sac. The more common sites of a congenital hernia which are present at birth in the probable order of frequency of occurrence are: (1) through the pleuroperitoneal hiatus (foramen of Bochdalek); (2) through the esophageal hiatus; (3) through an anterior substernal opening (foramen of Morgagni or Larrey's spaces), and (4) through the gap left by partial absence of the diaphragm, a gap which is usually situated in the posterior portion of the muscle.

If the hernia is acquired after birth, the sites of occurrence are: (1) through the esophageal hiatus (this type of hernia has a hernial sac); (2) through the region of fusion of the anlage of the diaphragm, and (3) at sites named under the congenital type in the foregoing paragraph.

Traumatic Hernia. Traumatic diaphragmatic hernia may be caused by direct or indirect injury, or by inflammatory necrosis of the diaphragm. In case of indirect injury of the diaphragm, the hernia may occur at any point, including points of embryologic fusion, but the most common sites are the dome and left posterior half of the diaphragm. On the other hand, the injury may occur in the right part of the diaphragm. This usually is the result of a severe, crushing injury. When the hernia occurs through the esophageal opening, there is a sac, but when it occurs through the leaf of the diaphragm there usually is no sac. In case of direct injury of the diaphragm, the hernia may occur at any point and is usually the result of penetrating wounds, such as those inflicted by a gun or knife.

Rupture of the diaphragm may be the result of inflammatory necrosis which, in turn, has been caused by subdiaphragmatic

TABLE I

DATA CONCERNING SITUATION, ETIOLOGY AND CONTENTS OF HERNIA

Site of Opening	Cases	Causation	Cases	Contents of Hernia	Cases
Esophageal hiatus	223	Congenital (history of trauma, 17)	223	Stomach (omentum) Stomach, omentum and spleen Stomach and colon	212 4 7
Short esophageal type	14	Congenital	14	Stomach only	14
Hiatus pleuroperitonealis	7	Congenital	7	Colon and small bowel Colon, small bowel, stomach and spleen	3 4
Absent posterior fourth of left diaphragm	5	Congenital	5	Stomach, colon, small bowel and spleen Colon and small bowel	3 2
Foramen Morgagni (subcostosternal)	4	Congenital	4	Omentum only Colon and omentum Omentum, cecum, appendix, colon and terminal ileum	2 1 1
Left hemidiaphragm (traumatic)	41	Trauma (indirect injury, 28; direct injury, 7); (inflammatory necrosis, 4)	41	Stomach only Stomach and colon Stomach, colon and small bowel Stomach, colon and spleen Stomach, colon, spleen and small bowel Stomach, colon, small bowel and liver Stomach, colon, small bowel, spleen and liver	5 10 7 2 9 4 4
Right hemidiaphragm	1	Trauma (indirect injury, 1)	1	Stomach, duodenum, colon, small bowel, liver (gallbladder) and head of pancreas	1
Totals	295		295		295

abscess, or, again, rupture may follow necrosis caused by drainage tubes which have been introduced into empyematic cavities. In these cases the opening usually is situated in the posterior part of the diaphragm and there is no hernial sac.

Contents of Hernia. In general, the various types of diaphragmatic hernia can be divided clinically into two main classes, depending on the abdominal viscera which are involved. In the first class the stomach is the only abdominal viscus incorporated in the hernia; the hernia usually occurs through the esophageal hiatus. In the second class, the intestines with or without the stomach and other abdominal viscera are included in the hernia. Such a hernia usually is of traumatic origin and is caused by laceration of a normal diaphragm. It also may be of congenital origin and may result from structural deficiency of the diaphragm.

Types of Hernia Encountered in Clinic Series. In my experience in 295 cases in which surgical treatment was employed, the most common types of hernia are esophageal hiatus hernia, pleuroperitoneal hiatus hernia, hernia attributable to congenital absence of the posterior portion of the diaphragm, subcostosternal hernia and

traumatic hernias caused by direct or indirect injury and those caused by inflammatory necrosis (Table 1).

stomach usually is the only abdominal viscus involved in the hernia. This type of hernia may progress until the entire stom-

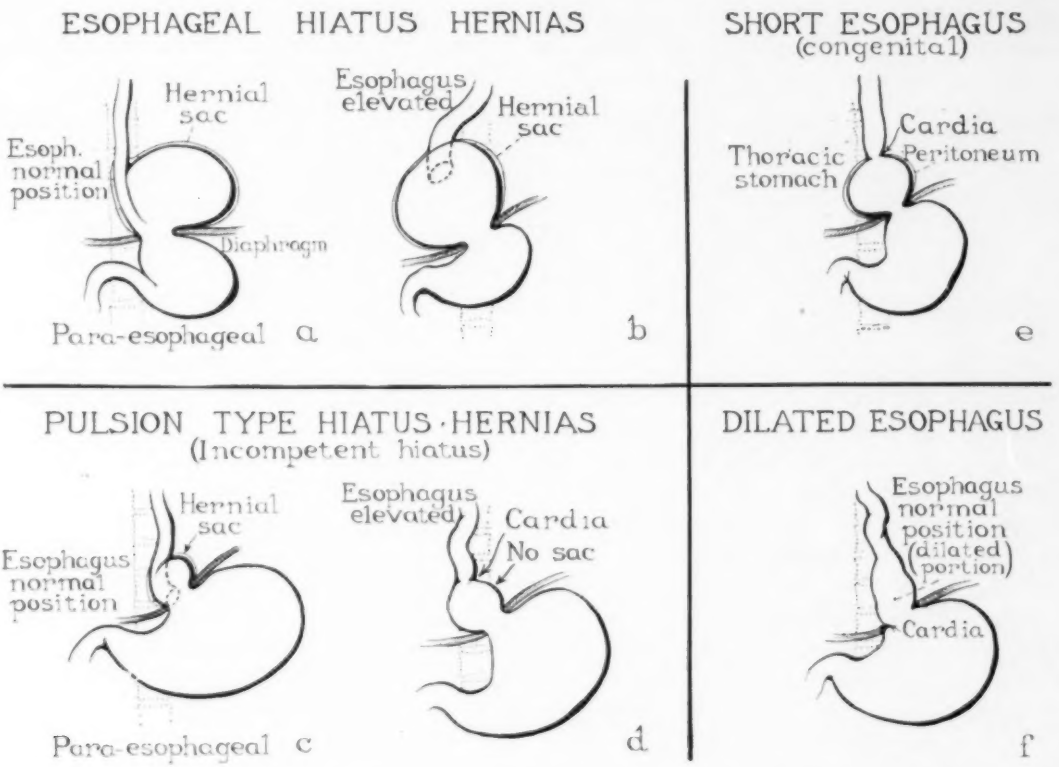

Fig. 1. Diagrammatic drawings of different types of esophageal hiatus hernia and some of the conditions which may simulate hiatus hernias roentgenologically. *a*. Esophageal hiatus hernia with herniation of the cardiac end of the stomach through the esophageal hiatus. Esophagus in normal position (para-esophageal hernia). *b*. Esophageal hiatus hernia in which there is herniation of the greater portion of the stomach through an enlarged esophageal hiatus into the posterior mediastinum and associated elevation of the esophagus. *c*. Slight protrusion of the cardia of the stomach through the hiatus with slight elevation of the lower part of the esophagus to the upper margin of the esophageal hiatus. This is a pulsion type of hernia with incompetent hiatus. *d*. Protrusion of cardiac end of the stomach through the esophageal hiatus and marked elevation of the esophagus into the posterior mediastinum; incompetent hiatus. *e*. Congenital, short esophagus with partial thoracic stomach. This is not a true hernia. *f*. Dilatation of the lower end of the esophagus, cardiac antrum. This is not a hiatus hernia. (From Harrington, S. W. Diagnosis and treatment of various types of diaphragmatic hernia. *Am. J. Surg.*, 1940, *50*, 377–446. Courtesy of the American Journal of Surgery, Inc.)

ESOPHAGEAL HIATUS HERNIAS

Esophageal hiatus hernia is the most common kind of herniation occurring through the diaphragm that is found among adult persons (Fig. 1). This type of hernia is slowly progressive and is a sliding herniation of the stomach into the posterior part of the mediastinum. It may push into either or both sides of the thoracic cavity, but does not enter the pleural cavity. The mach is contained within the hernial sac; the colon, omentum, and occasionally the spleen also may be drawn into the hernial sac.

I believe it is best to classify all true hernias through the esophageal hiatus under the one term "esophageal hiatus diaphragmatic hernia." True esophageal hiatus hernias can be classed into two types: in the first type the esophagus is of normal

length and its lower end is not elevated above the diaphragm, but a portion of the stomach has herniated into the posterior mediastinum, beside the esophagus. This type of hernia is often designated as para-esophageal hiatus hernia. The hernias are usually small to moderate in size and rarely involve more than a fourth to a half of the cardiac end of the stomach, which is contained in the hernial sac. About a third of the esophageal hiatus hernias on which I have operated were of this type.

In the second type of esophageal hiatus hernia, the esophagus is of normal length but its lower end is elevated above the level of the diaphragm, and the herniated stomach is in the posterior mediastinum. The size of the hernias is usually larger than that of the first type. From a third of the stomach to the entire stomach, portion of the omentum and occasionally a portion of the colon, are within the hernial sac. These hernias usually fill the entire mediastinum and generally project into the left side of the thoracic cavity but they may project into the right side of the thoracic cavity or into both sides. Hernias of this type constitute about two-thirds of the esophageal hiatus hernias on which I have operated.

The essential difference between these two types is one of degree rather than any fundamental difference in origin. Inasmuch as these hernias are progressive in character and are in reality a sliding type of hernia, hernias of the first type may ultimately develop into those of the second type as more of the stomach is included in the hernial sac. In many cases of esophageal hiatus hernia there is dilatation of the lower end of the esophagus. This is usually more marked in the larger types of hiatus hernia.

With the more frequent roentgenologic recognition of small esophageal hiatus hernias in the last few years, two additional types have been recognized which may be considered pulsion types of esophageal hiatus hernia. In these types a small portion of the cardiac end of the stomach projects through the esophageal hiatus. These hernias are probably attributable to atrophy of the elastic fibers of the diaphragmatico-esophageal membrane together with relaxation of the circular muscle surrounding the esophageal opening, with a resultant incompetent hiatus. Recognition and differentiation of these two types are often difficult by roentgenologic examination alone. The establishment of the diagnosis is aided by an esophagoscopic examination which is often essential in arriving at an accurate diagnosis. These hernias are more commonly seen among elderly persons. In many instances the finding of these hernias is incidental, for the patients do not present any subjective symptoms. However, in the instances in which the symptoms are severe and do not respond to conservative measures, surgical intervention is necessary for relief.

Hernias of the third type closely simulate the para-esophageal type of hernia except that they are relatively small. A definite hernial sac is beginning to form. The esophagus is only slightly elevated; the abdominal portion is elevated to the superior border of the diaphragm. The hernia may remain small or it may develop into a true para-esophageal hernia.

In the fourth type the entire hiatus is incompetent, the cardiac end of the stomach protrudes like a funnel above the diaphragm and there is a comparable elevation of the esophagus which enters the apex of the protruded portion of the stomach. This type does not have a true hernial sac and may not be considered a true hernia. This type of hernia can be distinguished in diagnosis from a congenital short esophagus with a part of the stomach in the thorax and dilatation of the lower end of the esophagus. This is best accomplished by an esophagoscopic examination to determine the length of the esophagus.

CONGENITAL SHORT ESOPHAGUS

In congenital short esophagus because of congenital malformation, the esophagus is not long enough to permit the stomach to reach its normal position below the diaphragm. The stomach is held suspended in the posterior mediastinum above the diaphragm. In this type of case the abnormal-

ity is often considered to be an esophageal hiatus hernia, but it is not a true hernia as the stomach has never been below the diaphragm. I believe the condition could be better described as a congenitally short esophagus with partial thoracic stomach. In my experience this condition is relatively rarely found at operation. I have operated on 11 patients who presented all of the roentgenologic signs of short esophagus but at the time of the operation I found that in 4 cases the esophagus, although its lower end was above the diaphragm, was sufficiently long to reach below the diaphragm when the herniated portion of the stomach was placed below the diaphragm. Of the remaining 7 cases, in 3 there was a slight shortening of the esophagus associated with herniation of the cardiac end of the stomach and the remaining 4 were cases of true short esophagus with partial thoracic stomach. In all but one it was possible to bring the stomach entirely below the diaphragm after separation of the attachments around the hiatus and the elevation of the diaphragm resulting from interruption of the phrenic nerve. In 1 case it was impossible to bring the stomach entirely below the elevated diaphragm and it was necessary to suture a small portion of the cardia into the hiatus when the hiatus was closed. This indicates that it is not always possible by roentgenologic methods to determine the type of hernia present. I believe that this condition, although rare, is an entity and should not be grouped with the true esophageal hiatus hernias.

This condition of short esophagus, from an etiologic standpoint falls into two classes: first, that in which the esophagus is congenitally short, which has been described, and second, that in which ulceration and occasionally malignant neoplasm of the esophagus have caused cicatricial contraction of the lower end of the esophagus. The cicatricial contraction draws the cardia of the stomach above the diaphragm, and the condition usually is associated with stenosis of the lower part of the esophagus.

In considering cases of short esophagus from a surgical standpoint, it is important not to confuse them with true esophageal hiatus hernias, for their surgical management is entirely different. In cases of true hernia, the surgical problem is that of replacement of the herniated viscera, removal of the hernial sac and repair of the abnormally enlarged esophageal hiatus. In cases of congenital short esophagus the surgical problem is that of reconstruction and elevation of the diaphragm to a position above the stomach; this can be accomplished if the congenital shortening of the esophagus is not too great. In those cases in which the stomach is elevated above the diaphragm because of traction of cicatrices following ulceration, the symptoms usually are relieved by dilatation of the stenosed esophagus. In those cases due to malignant neoplasms, radical removal of the lesion of the esophagus is to be considered.

DILATATION OF THE LOWER END OF THE ESOPHAGUS WITH RELAXATION OF THE CARDIA OF THE STOMACH

This condition not uncommonly simulates esophageal hiatus hernia of the pulsion types both roentgenologically and clinically. In order to establish a definite diagnosis it is usually necessary to examine the esophagus with an esophagoscope as well as to carry out roentgenologic examination. At the time of the esophagoscopic examination, a specimen of tissue can be removed from the wall at the site of dilatation and studied to determine whether it is squamous cell epithelium of the esophagus or gastric mucosa of the stomach. It is important to differentiate dilatations of the lower part of the esophagus from hiatus hernias as surgical intervention is not indicated in cases of dilatation of the esophagus.

CONGENITAL DIAPHRAGMATIC HERNIA DUE TO STRUCTURAL DEFICIENCIES OF THE DIAPHRAGM (PLEUROPERITONEAL HIATUS HERNIA AND CONGENITAL ABSENCE OF POSTERIOR PORTION OF DIAPHRAGM)

Congenital diaphragmatic hernias attributable to congenital deficiencies of the diaphragm are of two principal types. The

first type is the pleuroperitoneal hiatus type of hernia and is due to a lack of fusion of the pleuroperitoneal membrane and septum transversum which results in an opening through the diaphragm. The second type, which is the congenital absence of the posterior portion of the diaphragm, is a much larger deficiency caused by lack of formation of the portion of the diaphragm resulting from the pleuroperitoneal membrane and possibly the wolffian body. There are various gradations of the amount of defect so that the size of the opening varies with the amount of the deficiency of the formation of the diaphragm.

The opening in the first type is usually situated in the costal angle posteriorly at the junction of the middle and posterior thirds of the diaphragm. This opening may extend to the chest wall and is usually somewhat triangular with the apex toward the middle portion of the diaphragm, or it may be entirely within the structure of the diaphragm where it is usually more or less elliptical. In this type of hernia the abdominal viscera which usually are involved in the hernia are the cecum, appendix, the ascending colon, greater portion of the transverse colon and practically all of the small bowel. In the larger hernias which present posteriorly, the spleen may be involved. The stomach is usually in the abdomen; it may be dilated markedly and at times extends to the pelvis.

In the second type of hernia associated with congenital absence of the posterior portion of the diaphragm, the same abdominal viscera are involved as in the pleuroperitoneal hiatus type of hernia; these are the ascending and transverse colon, small bowel and in addition usually the stomach, spleen and left kidney. The roentgenologic examination is often misleading in this type of hernia, for in many instances at the time of the roentgenologic examination the stomach is found to be in the abdomen and at the time of operation it is found to be herniated in the left side of the thorax. This, I believe, is due to the weight of the barium which causes the stomach to drop into the abdomen where undoubtedly it is a great deal of the time during life. It doubtless goes back and forth through the large opening posteriorly at the point where it extends up to the esophageal hiatus. Because of the roentgenologic findings of the stomach in the abdomen, this type of hernia may be thought to be a true pleuroperitoneal hiatus type of hernia rather than that produced by congenital absence of a larger portion of the diaphragm. The position of the left kidney as shown by the renal shadow or pyelogram may be helpful in differentiating between these types of diaphragmatic hernia. In the pleuroperitoneal hiatus type of hernia the kidney is in its normal position below the diaphragm. In the type of hernia resulting from the absence of the posterior portion of the diaphragm, the kidney is usually elevated to a position above the normal diaphragm in the lower part of the thorax.

It is often difficult to determine the function of the diaphragm in hernias caused by structural deficiencies as the motion is usually obscured by the enormous amount of viscera contained in the thorax. When it can be visualized, there is usually some impairment in normal function.

These hernias do not have a hernial sac and the abdominal viscera are in direct contact with the thoracic cavity. They produce marked or complete collapse of the left lung and often marked shift of the mediastinum to the right. This shifting of the mediastinum depends on the amount of distention of the herniated viscera.

I believe that operation should be performed for these congenital types of hernia as soon after birth as the condition is recognized, for the longer the interval between birth and operation the greater the technical difficulties and the greater may be the hazard of operation. Inasmuch as a high percentage of infants born with these types of congenital hernia die the first few hours or days of life from cardiac or respiratory difficulty, I believe operation should be performed as soon as a diagnosis is established; which often can be done by taking

a roentgenogram of the thorax. At birth the defect is relatively smaller in proportion to the size of the thorax than it is later in life. In infants who live, the chest wall grows away from the posterior margin of the defective diaphragm because there is no posterior attachment. The opening therefore which must be closed is much larger as the child becomes older. Even though the diaphragmatic muscle is relaxed by interruption of the phrenic nerve, there may not be sufficient diaphragm to span this opening. In some instances an extrapleural rib resection also is necessary to narrow the diameter of the thorax in order to close the opening.

One of the chief dangers associated with the repair of these hernias is marked alteration of intrathoracic or intra-abdominal pressure. It is important in these cases that the respiratory function be maintained by positive pressure during the operation and that at the completion of the operation a negative pressure be obtained and secured in the thoracic cavity. A roentgenogram should be taken at the completion of the operation to see that there is no shift of the mediastinum caused by the pneumothorax. I do not permit the patient to leave the operating table until I have seen the roentgenogram. If there is any shift in the mediastinum, more air is withdrawn to maintain the mediastinum in the midline as shown by further roentgenograms.

SUBCOSTOSTERNAL (FORAMEN OF MORGAGNI) DIAPHRAGMATIC HERNIA

The clinical recognition of this type of hernia is usually entirely dependent on roentgenologic examination. From the roentgenologic standpoint the diagnosis may be established readily or it may be impossible to establish a definite diagnosis depending on the kind of the abdominal viscera involved in the hernia. The defect in the diaphragm is anterior at the attachment of the diaphragm to the thoracic wall. The hernial opening may be bilateral, but it is usually unilateral and a little to the right of the midline beneath the lower part of the sternum and right costal cartilages. The abdominal viscera usually involved in the hernia are the omentum and the omentum and colon which are enclosed in a hernial sac of peritoneum. This extends into the thoracic cavity beneath the pleura but does not enter the true pleural space.

When the colon is involved in the hernia the roentgenologic diagnosis is readily established. The colon is visualized immediately beneath the right anterior wall of the chest and may extend to the apex on the right side of the thoracic cavity. In one instance in which there was a nonrotation of the colon, I have seen the ileocecal coil in this type of hernia.

When the omentum is the only abdominal structure involved in the hernia, the roentgenologic diagnosis is difficult and may be impossible to establish definitely. The roentgenologic findings are those of increased density at the cardiophrenic angle anteriorly, usually on the right and are commonly thought to be due to an intrathoracic tumor. In some instances the true diagnosis can be suspected by roentgenologic examination of the colon which shows the colon drawn up toward the abdominal side of the opening but the elevated portion of the colon is not always present and the colon may be in normal position in the abdomen. I have operated on 3 patients who had hernias of this type which had been diagnosed elsewhere as intrathoracic tumors. In 1 of these the diagnosis of intrathoracic tumor was confirmed at the Clinic. On transpleural exploration the lesion was found to be an omental subcostosternal hernia. I also have operated on 1 patient who was thought to have an omental subcostosternal hernia, but proved to have a cystic mediastinal tumor at the costophrenic angle anteriorly. If the omental hernia is large, the clinical symptoms also may suggest the diagnosis of thoracic tumor because of the pulmonary symptoms due to pressure causing partial collapse of the lung. In the smaller types of hernia containing omentum only, there are usually no sub-

jective symptoms and the diagnosis is usually established at operation.

TRAUMATIC DIAPHRAGMATIC HERNIA

These hernias may result from direct or indirect injury to the diaphragm and are probably the most readily recognized clinically as well as roentgenologically of all types of diaphragmatic hernia. The hernia may occur in either the right or the left side of the diaphragm but it occurs much more commonly in the left side. The laceration may occur in any portion of the diaphragm but it is most common in the posterolateral portion and dome of the diaphragmatic muscle. The laceration may extend across the entire leaf of the diaphragm and occasionally extends into the opposite side of the diaphragm. These lacerations occasionally split the esophageal hiatus but in most instances the circular muscle of the hiatus remains intact. There is usually only one opening but there may be multiple openings. The laceration is usually in the suspended portion of the diaphragm but occasionally may involve the attachment of the diaphragm to the wall of the chest. In some instances the attachments may be almost completely torn from the chest wall. The laceration involves the entire width of the diaphragmatic muscle producing a direct communication between the abdominal and the thoracic cavity and there is no hernial sac. The condition may be more properly termed an evisceration than a true hernia.

Any of the abdominal organs except those in the pelvis may be involved in these hernias. The most common are the stomach, large and small bowel, spleen and liver. Roentgenologically the entire thoracic cavity is seen to be filled with hollow viscera which may extend to the apex of the thorax causing almost complete collapse of the lung with marked displacement of the mediastinum. In lacerations in the right half of the diaphragm the shadow of the liver may be seen above the diaphragm. It is usually difficult to determine the situation of the laceration in the diaphragm or the function of the diaphragm by roentgenologic examination because of the presence of the mass of herniated viscera which obscures the diaphragmatic muscle. Lacerations of the diaphragm involving the esophageal hiatus may be suggested roentgenologically by elevation of the lower end of the esophagus with the cardia of the stomach into the thoracic cavity.

Inflammatory Necrosis. This type of hernia may be termed a "traumatic hernia" and is one of the rarest types of diaphragmatic hernia. It is produced by an inflammatory necrosis of the diaphragm caused by rupture of a subphrenic abscess through the left half of the diaphragm. The acute condition may have preceded the diagnosis of hernia by months or years. These hernias usually occur in the dome of the diaphragm and do not involve the hiatus; they do not have a hernial sac. The stomach or stomach and bowel may be involved in the hernia. While the diagnosis is essentially a clinical consideration these hernias do have some suggestive roentgenologic findings; namely, there is a relatively small portion of stomach or bowel involved in the hernia; a small segment of stomach may be herniated through the diaphragm, and the herniated viscera are very adherent to the hernial opening and to the under surface of the lung.

These hernias often present a difficult surgical problem because of the enormous number of adhesions fixing the herniated abdominal viscera to the diaphragm, which require careful dissection. There is often some loss of structure and thinning out of the diaphragmatic muscle. These hernias are repaired by overlapping the margins of the opening after carefully dissecting the viscera from the diaphragm and the margins of the opening.

POSTOPERATIVE MANAGEMENT

Roentgenography is also important in the immediate and subsequent postoperative management of surgical patients.

At the completion of all operations for diaphragmatic hernia, I routinely have roentgenograms made and read before the

patient is taken from the operating room. It is extremely important to determine the presence or absence of any abnormal condition or position of the intrathoracic viscera and if some abnormal condition is present, it should be corrected before the patient leaves the operating table.

Two of the more important immediate postoperative conditions which imperil the recovery of the patient following operation are displacement of the mediastinum to the side opposite the operation, and pulmonary congestion. If these conditions are present, they seriously interfere with cardiac and respiratory function and the result may be death if they are not immediately relieved. Mediastinal displacement is due to pneumothorax and must be relieved immediately by the withdrawal of sufficient air to produce a negative intrathoracic pressure and bring the mediastinum to the midline.

Pulmonary congestion is due to the retention or aspiration of secretions and is best relieved by immediate bronchoscopic aspiration of the lung.

Patients who require immediate postoperative treatment should have a second roentgenogram made and read after the treatment has been instituted to be certain the condition has been corrected before they are taken from the operating table.

One of the important subsequent postoperative conditions that may develop is pleural effusion from trauma of the pleura. The pleural effusion may be slight and gradually absorb and require no treatment. It may become progressively more marked causing respiratory and cardiac difficulty and require pleurocentesis.

COMMENT

I do not believe it is possible to overestimate the value of roentgenography in the diagnosis and treatment of diaphragmatic hernia. The advent of roentgenography made possible the clinical diagnosis. The marked improvement in roentgenologic methods of diagnosis which has taken place in recent years is of great value in the clinical and surgical management of this group of cases. I am certain that increased knowledge which is now obtainable before operation in regard to these hernias is an important factor in decreasing the operative mortality which is relatively small considering the magnitude of many of these operative procedures. In this series of 295 operated cases there were 12 deaths, or a mortality of 4 per cent.

DISCUSSION

Dr. B. N. Carter, Cincinnati, Ohio. It is fitting that the subject of hernia through the diaphragm be discussed before a group of roentgenologists, for it is largely due to the improvement in their technique, to their interest, and to their endeavor that diaphragmatic hernia has reached its present position of prominence in the surgical world. In many instances the diagnosis based on signs and symptoms is extremely difficult because the disease so readily simulates many other conditions in the respiratory tract or gastrointestinal symptoms. Both roentgenography and roentgenoscopy are important in establishing the diagnosis, but even with their help the diagnosis may often be missed or long delayed. It is the old story of first thinking of the disease, after which the diagnosis may be ruled in or out. We are now becoming more and more conscious of the condition of diaphragmatic hernia and consequently we should diagnose it more and more accurately in the future.

Few surgeons have been as fortunate as Dr. Harrington in seeing and treating such a large number of cases of diaphragmatic hernia. He has been able to formulate certain rules of management and of operation which have been of the greatest benefit to surgeons everywhere; for example, his classification of diaphragmatic hernia is sound and is the accepted one at present. Many points in the technique of his operation have been universally adopted. Rather than attempt a general discussion of his paper, I will focus my attention on one or two aspects of the subject.

In the first place, it seems to me to be essential to look at congenital diaphragmatic hernia from the point of view of the *age* of the given patient as well as of the anatomy of the condition. I say this because the treatment of a given case depends considerably on this fact. It has been estimated that 75 per cent of infants with congenital hernia through the diaphragm die before

the end of their first month of life, and that a further number of the remaining 25 per cent die of their disease during the early years of childhood. On the other hand, if a given patient has survived his childhood, the chances are great that he will live out his normal span of life in spite of the hernia, though he may be greatly inconvenienced by it. The surgical significance of these facts from the point of view of treatment is very clear, namely, infants born with diaphragmatic hernia have their best chance of survival if they are operated upon as promptly as possible after birth, whereas older patients may be temporized with, treated palliatively, and operated upon when such a procedure is indicated. There is obviously little excuse for expectant treatment in the case of infants with diaphragmatic hernia if 75 per cent of them are going to die under such therapy. Infants stand operative procedures surprisingly well and I feel that early operation offers them their best chance. This fact is not appreciated widely enough either by pediatricians or by general surgeons.

In the second place, I would like to say a word or two about congenital diaphragmatic hernia occurring on the *right* side. These hernias are rare, and are said to occur in about 9 per cent of all congenital hernias. Such hernias usually occur through the parasternal space, though occasionally they may be seen to enter the chest through the pleuroperitoneal space. The presence of the liver beneath the diaphragm is probably the reason for the small number of hernias occurring through the right diaphragm. The most common viscus involved in right-sided hernia is the transverse colon, and since the opening in the diaphragm at the parasternal space is small, obstruction is very apt to occur in these cases. The two parasternal hiatuses lie one on each side of the xiphoid process. A hernia coming through the left hiatus may push its way into the right chest, and vice versa. These two facts are strong indications for the abdominal operative approach to parasternal hernias. A transthoracic approach is difficult because the opening in the diaphragm is inaccessible through the thorax and also because, if the hernia comes through an opening on the left side and has pushed its way into the right, obviously one would have to go through the anterior mediastinum into the opposite chest in order to close the defect.

Personally, I prefer and have used the transthoracic approach in all the cases of hernia through the diaphram which I have operated upon, except the parasternal ones. I like this approach because it gives a wide and easy exposure to the diaphragm, because sutures can be placed accurately from above without fear of damaging the heart, great vessels, and esophagus. I recall vividly one traumatic diaphragmatic hernia which I did transthoracically. The tear in the diaphragm extended right to the lower surface of the pericardium. Had I been below the diaphragm, I believe I would certainly have damaged the heart in my attempt to suture the rent in the diaphragm. If there are adhesions present, as is commonly the case in chronic traumatic hernia, the transthoracic approach is much preferable. It is said that reduction of the hernial content is difficult through the opening in the diaphragm if one is working through the thorax. I have not found this to be the case except in one instance where, after enlargement of the ring, the hernia was readily reduced. By opening the ring widely one can explore the upper abdomen easily and can be sure that the replaced intestine is in satisfactory position. If the transthoracic approach is used, it is a very simple matter to crush the phrenic nerve at this operation rather than perform a phrenicotomy in the neck. We crush the phrenic nerve in all of our operations and feel that this is important. The rest afforded the diaphragm makes the suturing of it a simpler matter and aids in the healing of the diaphragm.

Dr. Harrington (closing). I thank Dr. Carter for his discussion and am pleased that he has emphasized the importance of early operation in congenital diaphragmatic hernia and the difficulties which are occasionally encountered in establishing a diagnosis in the subcostosternal types of hernia, particularly in those cases in which the omentum is the only abdominal structure involved in the hernia. In these cases it is often impossible to differentiate this type of hernia from intrathoracic tumor. However, when the colon is involved in this type of hernia they are probably the most easily recognizable of all types of diaphragmatic hernia by the injection of opaque material into the colon showing it extending above the diaphragm from the right cardiophrenic angle along the anterior chest wall and usually extending into the right thoracic cavity.

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CARCINOMA OF THE HEAD OF THE PANCREAS DEMONSTRATING THE NEW SIGNS IN ROENTGEN DIAGNOSIS*

CASE REPORT

By PAUL S. FRIEDMAN, M.D.
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THE roentgen diagnosis of enlargement of the head of the pancreas, and in turn, of carcinoma of the head of the pancreas, was traditionally dependent upon gross changes such as marked widening of the duodenal curve. Recently, however, largely due to the efforts of Frostberg and Feldman, closer attention has been paid to the early mucosal changes in the duodenum accompanying enlargement of the head of the pancreas. They have, in particular, described an inverted 3 pressure filling defect, characteristically seen along the internal aspect of the duodenal curve, as well as accompanying distortion of its mucosal pattern, with changes in contour of the ampullary portion of the duodenum.

The following case report is interesting because of its demonstration of these signs. The operative and autopsy data are also interesting.

CASE REPORT

A white male, aged fifty-seven, was admitted to Jefferson Hospital with a history of persistent epigastric discomfort of about seven months' duration, accompanied by a gradually progressive yellowish discoloration of the skin, generalized pruritus, and weight loss of about 30 pounds.

Physical examination revealed the presence of emaciation and jaundice. The abdomen was scaphoid in type with moderate epigastric tenderness. The liver was firm and enlarged, extending to the right iliac crest.

Laboratory studies revealed a prolongation of prothrombin time which was remedied by the administration of vitamin K. Liver function was depressed, with a positive direct Van den Bergh, and a quantitative Van den Bergh of 16.4 mg.

Roentgen examination of the gastrointestinal tract revealed the pyloric antrum to be deformed and widened apparently by extrinsic pressure. The descending duodenum was noted to be somewhat rotated, with widening of its mucosal folds. On its lateral aspect, corresponding to its posterior wall, there was present a figure 3 filling defect (see Fig. 1 and 2). Incidentally, diverticula of the descending duodenum and upper jejunum were visualized.

FIG. 1. Demonstrating the figure 3 defect along the external aspect of the duodenum (see diagram).

At operation, a distended gallbladder with a dilated common bile duct about 5 cm. in diameter was found. The head of the pancreas formed a stony hard mass which involved the ampulla of Vater. On the under surface of the liver a firm white nodule was present. A choledocho-duodenostomy was performed.

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The patient died a week following operation, after a comparatively mild postoperative course with symptoms of fever, dyspnea, non-productive cough and chest pain.

Postmortem examination revealed an adenocarcinoma of the head of the pancreas, with metastases to the liver and hepatic hilar lymph nodes. The head of the pancreas was firm and enlarged, measuring 5 cm. in diameter. The immediate cause of death was an acute fibrinopurulent peritonitis, apparently due to leakage from the site of the choledocho-duodenostomy.

FIG. 2. Demonstrating distortion of the mucosal pattern of the duodenum (see diagram). Note the diverticulum along the external aspect of the duodenum.

COMMENT

A case of carcinoma of the head of the pancreas is presented, which demonstrates distortion of the mucosal folds of the duodenum, evidence of rotation of the duodenum and a figure 3 filling defect. This defect apparently represents evidence of pressure of the enlarged head of the pancreas upon the ampullary portion of the duodenum. In this case, although it was not as sharply demarcated as in some of the cases of Frostberg and Feldman, it was well visualized. However, instead of appearing as an inverted figure 3 defect along the internal aspect, it appeared as a figure 3 defect along the external aspect. This was due to the factor of rotation; the defect apparently represented pressure along the posterior wall of the descending duodenum, but due to the accompanying rotation of the duodenum it appeared externally. This rotation was further indicated by the presence of the duodenal diverticulum along the external aspect; it probably originated internally and was rotated externally.

Thus, the roentgen diagnosis here was largely dependent upon the distortion of the mucosal folds of the duodenum, evidence of rotation of the duodenum with displacement of a diverticulum to an external position; the presence of the figure 3 defect was interesting confirmatory evidence. Similar pressure upon the pyloric antrum was evident.

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Vol. 49, No. 2

THE DIAGNOSIS OF POSTERIOR PROTRUSION OF THE INTERVERTEBRAL DISC

WITH SPECIAL REFERENCE TO (1) ITS DIFFERENTIATION FROM CERTAIN DEGENERATIVE LESIONS OF THE DISC AND ITS RELATED STRUCTURES AND (2) THE INTERPRETATION OF CONTRAST MYELOGRAPHY*

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PHILADELPHIA, PENNSYLVANIA

AN EXTENSIVE literature has accumulated on the subject of lesions of the intervertebral disc and its adjacent structures, more particularly with reference to posterior protrusions of the intervertebral disc into the vertebral canal and/or intervertebral foramen (Saunders and Inman,[17] Bradford and Spurling[2]). Large series of cases, in which this latter lesion has been demonstrated at operation as a cause of low backache and the sciatic syndrome, have been reported from certain clinics (Love and Walsh,[15] Barr and Mixter,[1] Bradford and Spurling[2]). Although the diagnostic criteria for this lesion have been specifically defined, and although the enthusiasm of certain investigators regarding the beneficial results following laminectomy in these cases is reflected in their clinical reports, there remain certain features regarding both phases, diagnosis and therapy, which require clarification.

There are some observers (Semmes,[19] Bradford and Spurling,[2,20] Spurling and Grantham,[21] Dandy[5]) who feel that the diagnosis and accurate localization of posterior protrusion of the intervertebral disc may be determined in a high percentage of cases from the clinical signs alone, with or without the aid of a spinal fluid examination. Most investigators, however, continue to rely on the contrast myelographic study as an aid in the diagnosis and localization of this lesion. This examination, despite the criteria specified by Hampton and Robinson,[12] Robinson,[16] Hampton,[11] Camp,[3,4] and others, has not proved to be an infallible diagnostic measure even in their experienced hands, although the preoperative roentgenographic diagnoses have been substantiated at operation in well over 90 per cent of their cases. Such errors, however, as positive myelographic interpretations with negative operative findings, or negative myelographic interpretations in the presence of intraspinal lesions, demand elucidation. These difficulties are exemplified in the cases in Figure 1.

There are a certain number of cases of low back pain, with or without the sciatic syndrome which, in my experience and in the experience of others, have failed to make a satisfactory recovery, despite the removal of a demonstrable posterior protrusion of the intervertebral disc. The explanations offered for such failures have varied: the posterior disc protrusion might have recurred; there might have been other disc protrusions at other levels that were not recognized; the posterior disc protrusion might have been only partly or not at all responsible for the disabling syndrome; or the type of surgery performed (laminectomy) might have been insufficient. With regard to this last suggestion, it is noteworthy that Barr and Mixter[1] observed, in an extensive series of cases, that only 52 per cent of those patients who had had laminectomies without subsequent spine fusion had no complaints, but that 73 per cent of those who had had the combined operation considered their backs of normal strength. While Farrell and MacCracken[9] have even suggested that spine fusion alone

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might be as effective as laminectomy and spine fusion, it is unlikely that successful treatment of the root compression could omit the removal of the protruding disc material that is compressing the sciatic nerve components.

The following observations by the writer, in one hundred spines of humans whose ages had varied between forty and eighty years, may throw some light on these problems.

THE SIGNIFICANCE OF DEGENERATIVE LESIONS OF THE INTERVERTEBRAL DISC AND ITS RELATED STRUCTURES IN THE DIFFERENTIAL DIAGNOSIS OF POSTERIOR PROTRUSION OF THE INTERVERTEBRAL DISC

It is essential to recognize that other lesions, which are largely the result of degenerative processes that involve the intervertebral disc, ligamentum flavum, and the adjacent bony structures, may produce defects in an intraspinal column of contrast medium that are characteristic of an extradural lesion. These lesions are often asymptomatic (Horwitz,[13] Duncan, Seybold, Hotchkiss and Kahler[7]).

1. Posterior bulging of the entire intervertebral disc, without localized herniation, is a common finding in adult cadaver material. The entire disc, in these instances, invariably shows advanced degenerative disease. The posterior protrusion is formed not only by thinned disc material bulging dorsalward, but also by the underlying hypertrophied posterior margins of the adjacent vertebrae. In my material, posterior bulging of the annulus fibrosus across the entire width of the disc, without true herniation, was observed in 25 instances between the fifth lumbar and first sacral vertebrae, in 22 instances between the fourth and fifth lumbar vertebrae, in 12 instances between the third and fourth lumbar vertebrae, in 4 instances between the second and third lumbar vertebrae, in 2 instances between the first and second lumbar vertebrae, and in 1 specimen between the twelfth thoracic and first lumbar vertebrae (Fig. 2, *a* and *b;* Fig. 3, *c* and *d;* Fig. 4; Fig. 5, *a* and *b;* Fig. 6 and 7). Localized (unilateral) posterior disc protrusion, with evidence of degenerative disease of the remainder of the intervertebral disc, was observed in 5 instances (once each between the fifth lumbar and first sacral, the fourth and fifth lumbar, the third and fourth lumbar, and the first and second lumbar vertebrae, and twice between the second and third lumbar vertebrae) (Fig. 8 and 9).

2. Degeneration of the intervertebral disc with subsequent narrowing of the intervertebral space may be associated with a settling of the upper vertebral body downward and backward on the vertebral body below, so that the posteroinferior border of the upper vertebral body and the overlying disc material projects posteriorly into the neural canal. This apparent "posterior displacement of the vertebral body" is not infrequently exaggerated by bony proliferation of this posteroinferior margin. In my material, the posterior margin of the fifth lumbar vertebra extended posterior to that of the sacrum a distance of 2/16 inch or more in 11 specimens (Fig. 3, *a* and *b;* Fig. 5, *c* and *d;* Fig. 6 and 7).

3. Apparent forward bulging of the ligamentum flavum, often constricting the intervertebral foramen, has been demonstrated in some specimens to be due to forward projection of the ligamentum flavum, often of normal thickness, by marginal bony proliferation of the underlying facets of the apophyseal joint. In my material, this lesion was encountered between the fifth lumbar and first sacral vertebrae, in 4 specimens bilaterally and in 1 specimen unilaterally and on the right, and between the fourth and fifth lumbar vertebrae in 1 specimen bilaterally, and in 2 specimens unilaterally and on the right (Fig. 3, *c* and *d;* and Fig. 7).

That these lesions may be asymptomatic, even though they encroach upon the lumen of the neural canal, may be explained in the lumbar region by the fact that the vertebral canal is large in this region and that the cauda equina is displaced within a wide range before pressure

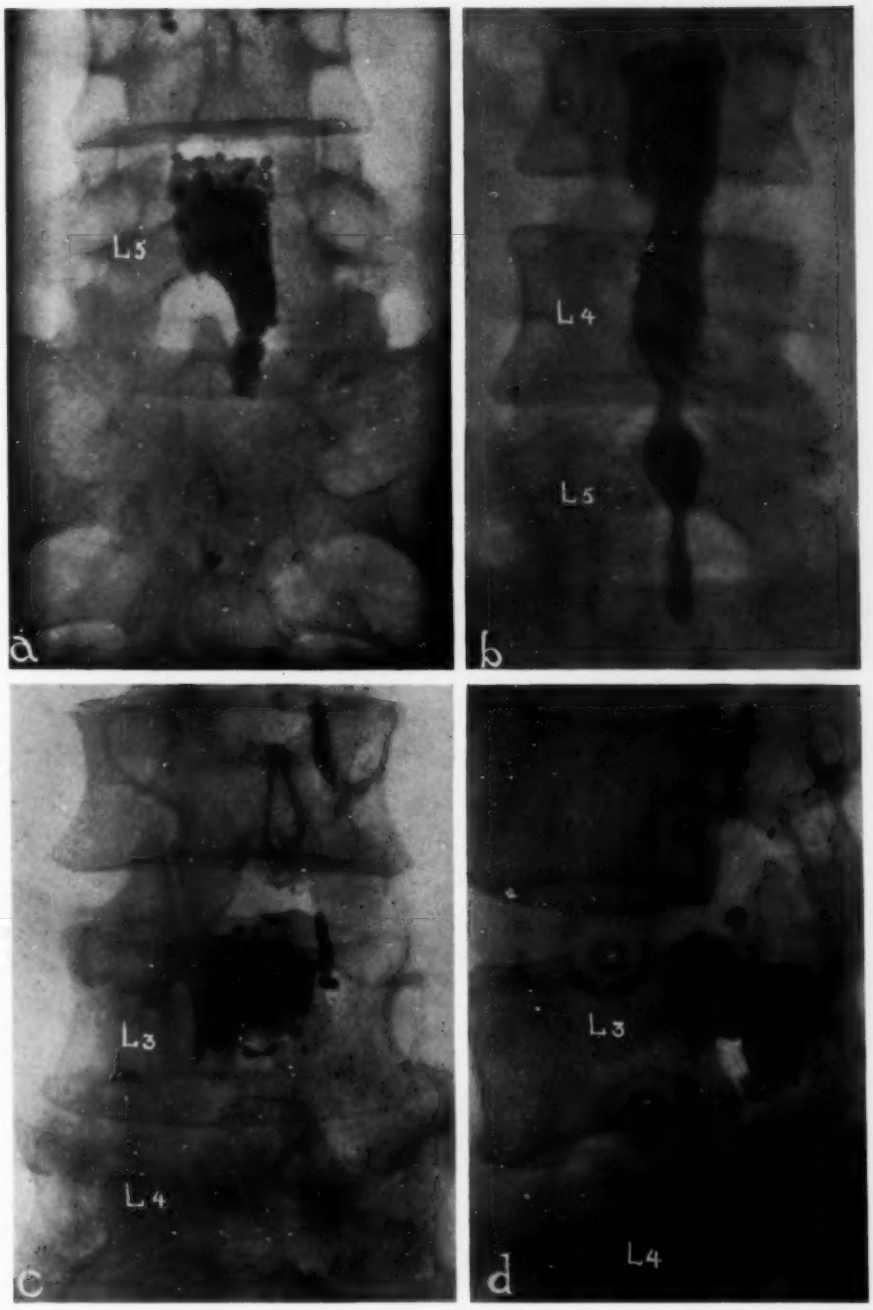

FIG. 1. Myelograms in (*a*) a twenty-seven year old female, (*b*) a thirty-nine year old female, and (*c* and *d*) a forty-four year old male, showing defects in the column of lipiodol which were constant. Each case presented a unilateral sciatic syndrome and a clinical picture consistent with a diagnosis of an intraspinal lesion, possibly a posterior protrusion of the intervertebral disc. Laminectomy, performed at the proper level in each instance, failed to disclose any intraspinal lesion. There was no demonstrable involvement of the intervertebral disc, and the ligamentum flavum was of normal thickness, with a normal histologic structure. Complete recovery, for no apparent reason, followed the laminectomy in case (*a*), partial recovery occurred in case (*b*), and there was no postoperative improvement in case (*c–d*).

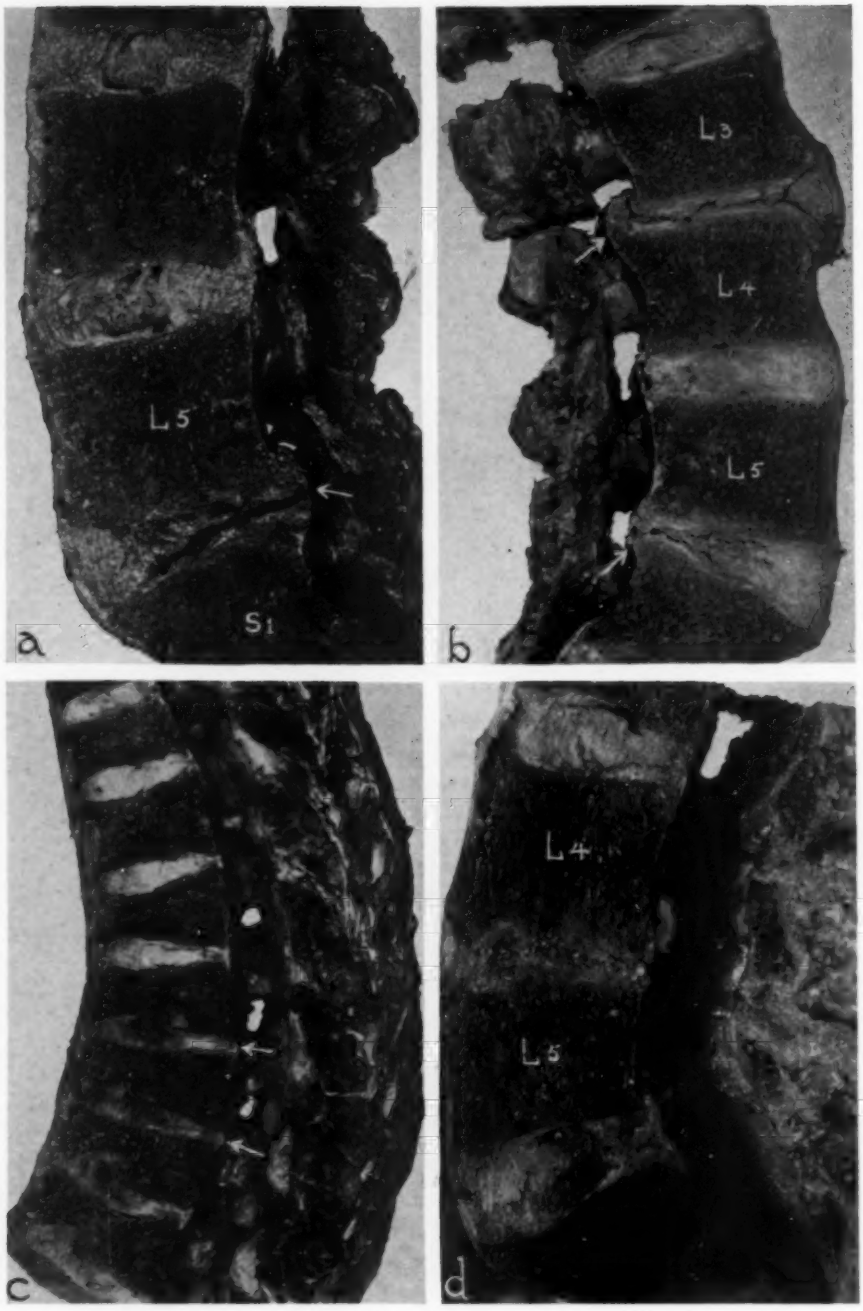

Fig. 2. Midsagittal sections of the lumbar spine in (*a*), (*b*) and (*d*), and of the lower thoracic spine in (*c*). Degenerative disease of the intervertebral disc with posterior protrusion into the spinal canal and encroachment of the corresponding intervertebral foramen is demonstrated in (*a*) between the fifth lumbar and first sacral vertebrae, and in (*b*) between the fifth lumbar and first sacral and between the third and fourth lumbar vertebrae. In (*c*) there is degenerative disease of many of the intervertebral discs of the lower thoracic segments, with protrusion of disc material into the spongiosa of the adjacent vertebral bodies. The arrows in this illustration indicate two slight posterior protrusions of disc substance. In (*d*) the intervertebral disc between the fourth and fifth lumbar vertebrae has undergone advanced degenerative changes —narrowing, dehydration, fragmentation, and "brown degeneration," but there is no demonstrable posterior protrusion of disc material.

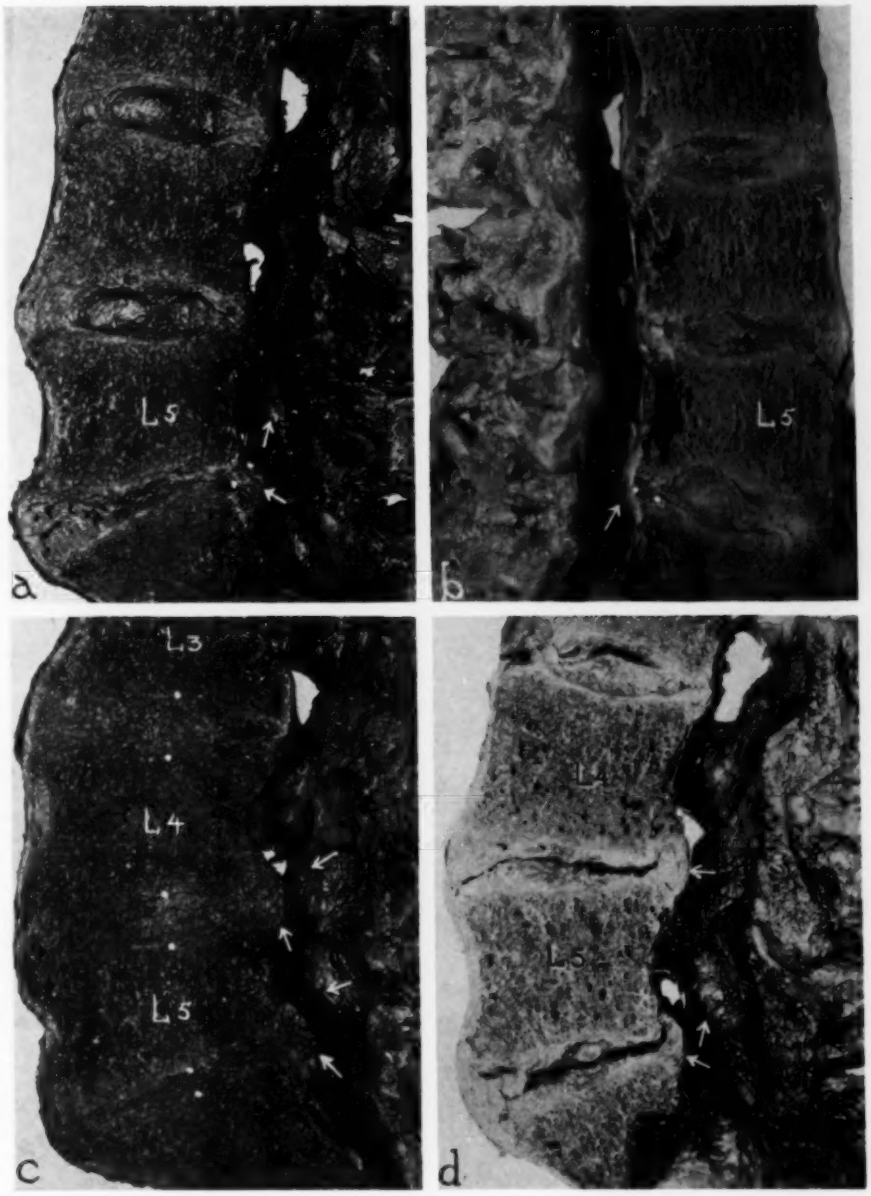

Fig. 3. Midsagittal sections of the lumbar spine. In (*a*) and (*b*) the posteroinferior margin of the fifth lumbar vertebra lies dorsal to the posterosuperior border of the sacrum, and, with the overlying disc substance, projects into the lumen of the spinal canal. In (*c*) and (*d*) there is advanced degenerative disease of all of the intervertebral discs with posterior protrusions at the level of the discs between the fourth and fifth lumbar and between the fifth lumbar and first sacral vertebrae. The forward bulging of the ligamentum flavum at these levels was shown to be due to hypertrophy of the underlying articular facets.

effects are produced, its components being fixed only at their origin and at their exit from the dural canal. This is well demonstrated by the absence of objective neurologic findings in most cases of advanced spondylolisthesis, in which lesion there is a marked encroachment on the neural canal. An intraspinal lesion in the cervical and thoracic regions, on the contrary, cannot assume much size without compressing some conductive nerve pathway and expressing itself clinically. In the cadaver

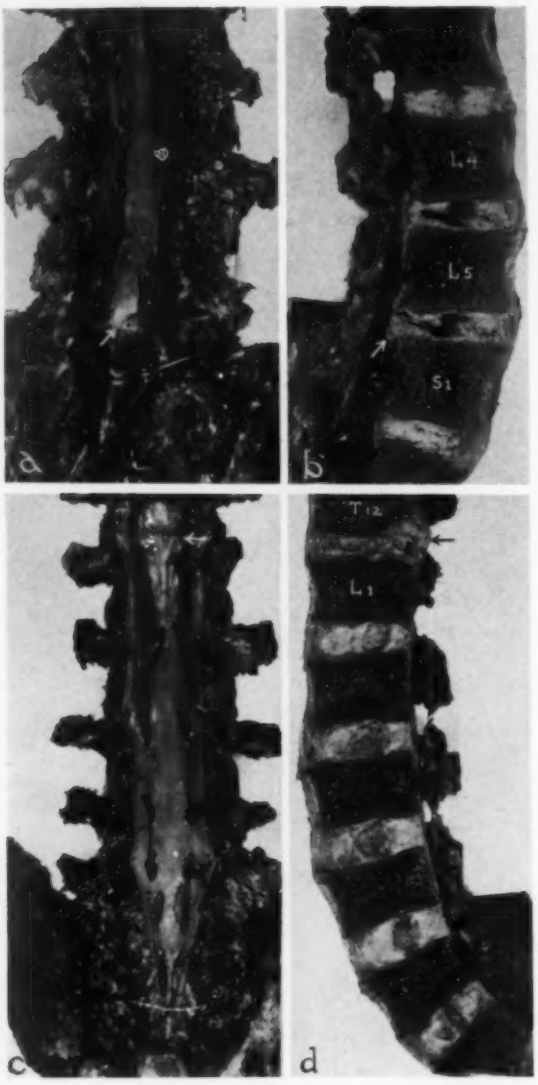

FIG. 4. In (*a*) and (*c*) the dural sacs of two lumbar spines have been opened posteriorly, following complete laminectomy; (*b*) and (*d*) are corresponding midsagittal sections.

The posterior protrusions of disc substance which are associated with degenerative disease of the disc between the fifth lumbar and first sacral vertebrae in (*b*) and between the twelfth thoracic and first lumbar vertebrae in (*d*) encroach at these levels on the lumen of the dural sac in (*a*) and in (*c*), respectively.

material of Duncan,[8] while the nerve roots and the spinal cord sometimes showed gross evidence of compression and deformity as a result of these degenerative lesions, no specific microscopic nerve changes were directly attributable to these lesions, and the changes were insufficient to account for functional disturbance.

There is a growing appreciation that the localized type of posterior protrusion of the intervertebral disc, to which a specific clinical picture is attributed and in which relief is often so spectacular following excision of the compressing lesion, not infrequently originates from the effects of trauma, single or repeated, *on an intervertebral disc that already demonstrates some degree of degeneration* (Saunders and Inman,[18] Donohue[6]). No consistent relation has been observed between changes such as narrowing of the intervertebral disc or marginal bony proliferation (lesions that manifest themselves on the ordinary roentgenogram of the spine) and the occurrence of posterior disc protrusions (Fig. 2, *d*; Fig. 10, *a* to *d*; Fig. 12, *c* and *d*). The majority of disc protrusions have been reported in patients in the fourth and fifth decades of life and involve the lower lumbar vertebrae, when and where degenerative phenomena are most common in the spine. The occurrence of multiple disc lesions in the same individual (Love and Walsh[14]) may be taken as evidence of the relation of this lesion to degenerative disease of the intervertebral disc.

MYELOGRAPHY IN THE DIAGNOSIS OF POSTERIOR PROTRUSION OF THE INTERVERTEBRAL DISC IN THE LUMBAR SPINE, AND THE DIAGNOSTIC LIMITATIONS OF THIS PROCEDURE

The anatomic features of the normal and abnormal myelograms of this lesion have been defined by Hampton and Robinson,[12] and Robinson,[16] and they have been corroborated in my anatomic material. The advantages and disadvantages of the various types of contrast media and, in the instance of iodized oil, the quantity of medium to be employed, are controversial subjects that will not be discussed in this presentation.

The Normal Myelogram. The spinal cord terminates in the conus medullaris at the

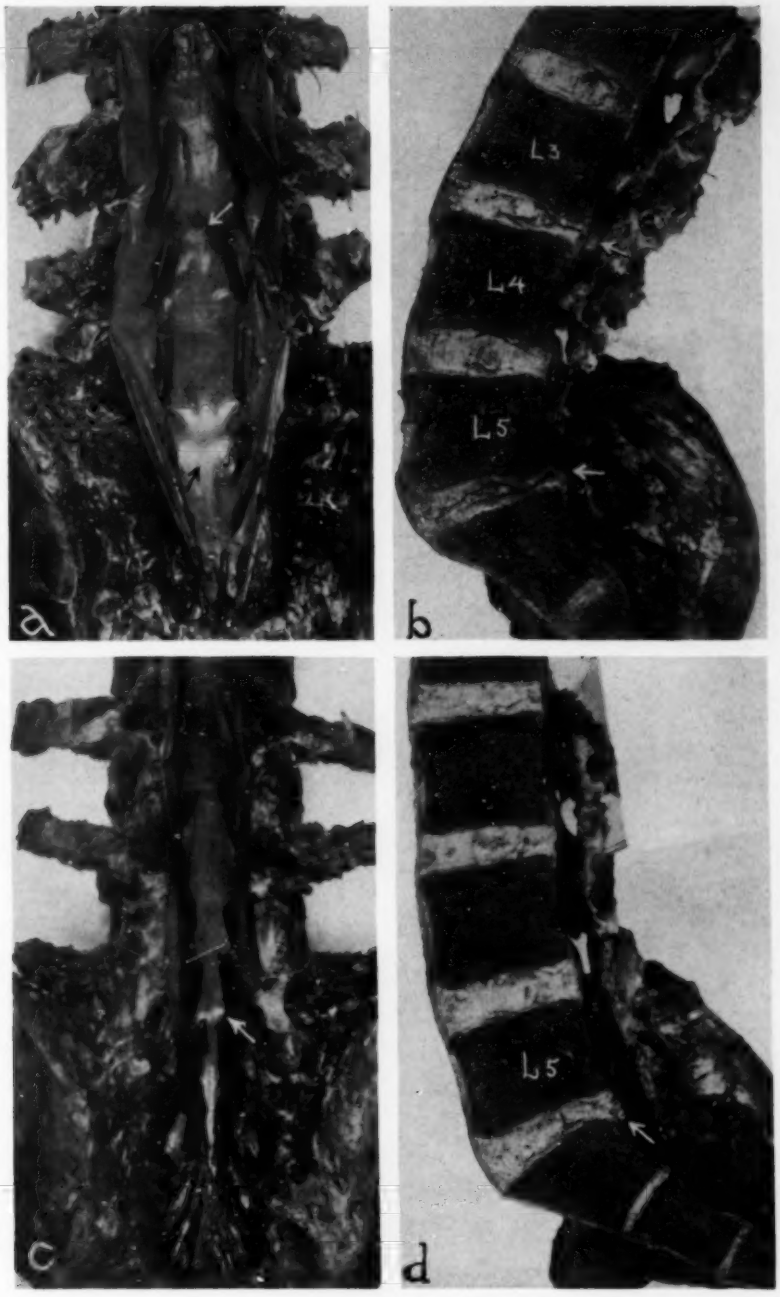

Fig. 5. In (*a*) and (*c*) the dural sacs of two lumbar spines have been opened posteriorly, following complete laminectomy; (*b*) and (*d*) are corresponding midsagittal sections.

The posterior protrusions of disc substance which are associated with degenerative disease of the discs between the third and fourth lumbar and between the fifth lumbar and first sacral vertebrae in (*b*), and between the fifth lumbar and first sacral vertebrae in (*d*), encroach at these levels on the lumen of the dural sac in (*a*) and in (*c*), respectively. The extradural defect in (*d*) is exaggerated by the downward and posterior displacement of the fifth lumbar body, so that its posterior border lies dorsal to that of the sacrum.

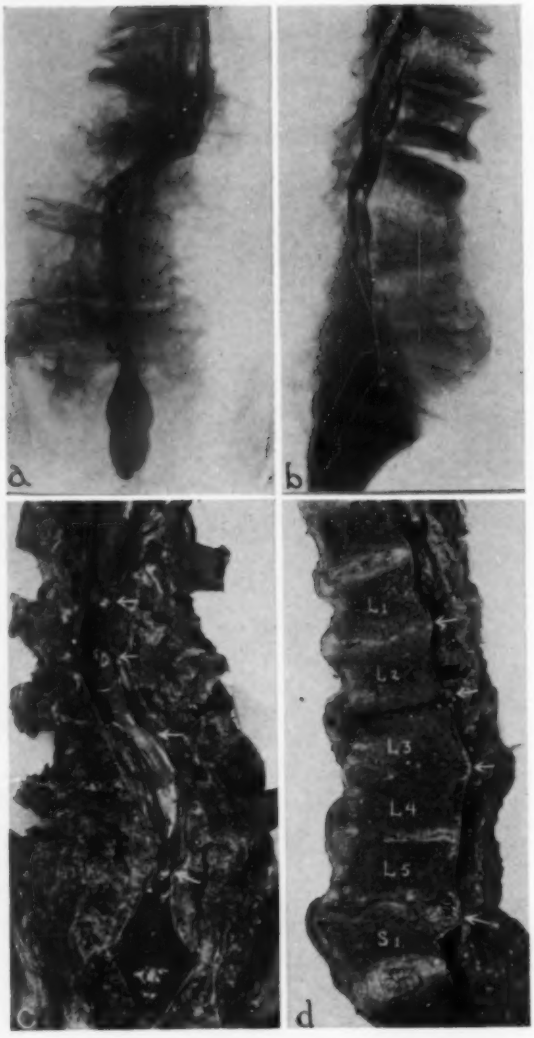

FIG. 6. (*a*) posteroanterior and (*b*) lateral lipiodol laminagrams, (*c*) intraspinal view after opening the dural sac posteriorly, and (*d*) midsagittal view of a lumbar spine with advanced degenerative disease of the vertebrae and the intervertebral discs. Attention is called specifically to the encroachments on the spinal canal, observed in all of these views, at the levels of all of the lumbar intervertebral discs, except that between the fourth and fifth lumbar vertebrae. The constricting lesion at the level of the lumbosacral disc is due, anteriorly, to posterior bulge of disc substance and the projecting posteroinferior margin of the fifth lumbar body, and, laterally, to proliferative changes in the zygapophyseal joints.

top of the second lumbar vertebra, and from its periphery arise the sensory and motor divisions of the lumbar and sacral nerve roots. The opaque medium, utilized in contrast myelography, is injected into the subarachnoid space, and is delimited externally by the arachnoid membrane and internally by the pia mater. Where a nerve root leaves the dural sac, it creates an out-pocketing or arachnoid pouch as it carries with it a portion of the three meningeal layers as its sheath. Due to the intimate contact of the nerve root to the lateral wall of the dural sac, some part of the root, rather than the wall of the lumbar sac, forms the lateral outline of the myelogram. The lateral, triangular-shaped projections correspond to the lower portions of the arachnoid out-pocketings that do not contain nerve root and therefore fill with contrast medium. The upper portion of these pouches fills only to a variable degree, but these "streaks" serve to delineate the nerve root. The apices of the triangular shadows demarcate approximately the termination of the dural sheaths of the nerve roots. Hampton and Robinson[12] and Robinson[16] have shown that, if the nerve outline is not distinct, this may be determined by utilizing the constant relationship that the lateral wall of the dural sac and the sheathed portion of the nerve root bear to the inner border of the bony pedicle (Fig. 11).

The Abnormal Myelogram. A defect in the outline of the contrast medium, to be of significance, must be constant and should be ascertained on more than one view. The size of a constant defect in the column of contrast medium does not predict the true size of the underlying pathologic lesion. Much of the lesion may be beyond the confines of the neural canal and it will therefore create only a minimal defect. On the other hand, the size of the defect may become exaggerated by changes in the nerve roots.

Since the majority of localized posterior disc protrusions present to one side of the midline, the classic defect on the myelogram will be a unilateral indentation which overlies, entirely or in part, the corresponding intervertebral space. The lesion, since it is anterior, will be visualized best in the prone and prone-oblique views. In the lateral view, this unilateral defect may be

overshadowed and obscured. Small midline protrusions may produce so minimal a central defect that they may be detected only by the critical study of the moving column of contrast medium; a large midline lesion may obstruct the column partially or completely. If the lesion extends across the entire width of the disc, there will be produced a bilateral defect on the posteroanterior view. A similar, symmetrical defect with a clear central channel will be produced by bilateral hypertrophy of the ligamentum flavum, and will also be produced by the degenerative type of disc lesion with posterior bulging of disc material and underlying hypertrophied bone, a lesion previously referred to (Fig. 2, 3, 4, 5, 6, 7 and 9). The basis for this "hourglass" type of defect is the triangular conformation of the neural canal in the lower lumbar spine. A unilateral defect, with its upper and lower limits sharply defined, may be produced by unilateral hypertrophy of the ligamentum flavum. It might also be produced by anterior bulging of a ligamentum flavum of normal thickness and overlying a hypertrophied articular facet (Fig. 3, *c* and *d;* and Fig. 7). In these instances the lateral view of the column of contrast medium will demonstrate an anterior or posterior indentation, or both, since disc and ligamentum flavum lesions may coexist. The abnormal myelogram may be further modified by evidence of nerve root displacement. In addition, evidence of edema of the nerve root may express itself by the additional indentation of the main column of contrast medium or by obliteration of the shadow of its nerve sheath and dural outpouching. Asymmetry of these axillary pouches may occur normally, and this defect, when constant, as with other constant defects in the myelogram, must be evaluated in the light of the clinical findings.

Possible Factors in Negative Myelography in the Presence of Positive Operative Findings.

1. Normal Anatomic Factors. These have been emphasized by Hampton and Robinson[12] and Robinson.[16]

a. The majority of posterior disc protrusions have been observed between the fourth and fifth lumbar vertebrae and between the fifth lumbar and first sacral vertebrae. Since the fifth lumbar nerve is intradural as it crosses the fourth lumbar disc, a posterior protrusion of this disc cannot compress this root without creating a defect in the outline of the lumbar sac. This root leaves the canal above the lumbosacral (fifth lumbar) disc, and it will not be affected by a posterior lesion of the latter disc. The first sacral nerve root acquires its sheath between the upper and lower borders of the lumbosacral disc and it is therefore not entirely within the lumbar sac in its course across this disc. A posterior disc protrusion at this level, therefore, may compress the first sacral root, or, if large enough, the other, more medially placed sacral roots, and still produce a minimal defect or no defect in the column of opaque medium (Fig. 11).

b. The arachnoid outpouchings are poorly defined at the lower end of the neural canal, since the nerve roots in this area descend almost vertically. Changes in their outline by pressure of an extradural lesion, therefore, cannot be easily determined (Fig. 11).

c. Another feature which makes the evaluation of a myelogram at or below the level of the lumbosacral disc more difficult is the normal lumbosacral angulation and sacral tilt, which causes the lower portion of the dural sac to be visualized "on-end" in the prone or supine positions (Fig. 11).

2. Anatomic Variations of the Cul-de-Sac. Camp[3,4] has called attention to two anomalies in this region that have accounted for errors of interpretation in some of his cases with negative iodized oil myelograms and positive surgical findings. In one type, the cul-de-sac terminated at about the level of the second sacral segment, but it was considerably narrower than normal below the level of the fourth lumbar intervertebral space. Although no instance of this anomaly was demonstrated in my cadaver material, I have observed the opposite variation, probably also de-

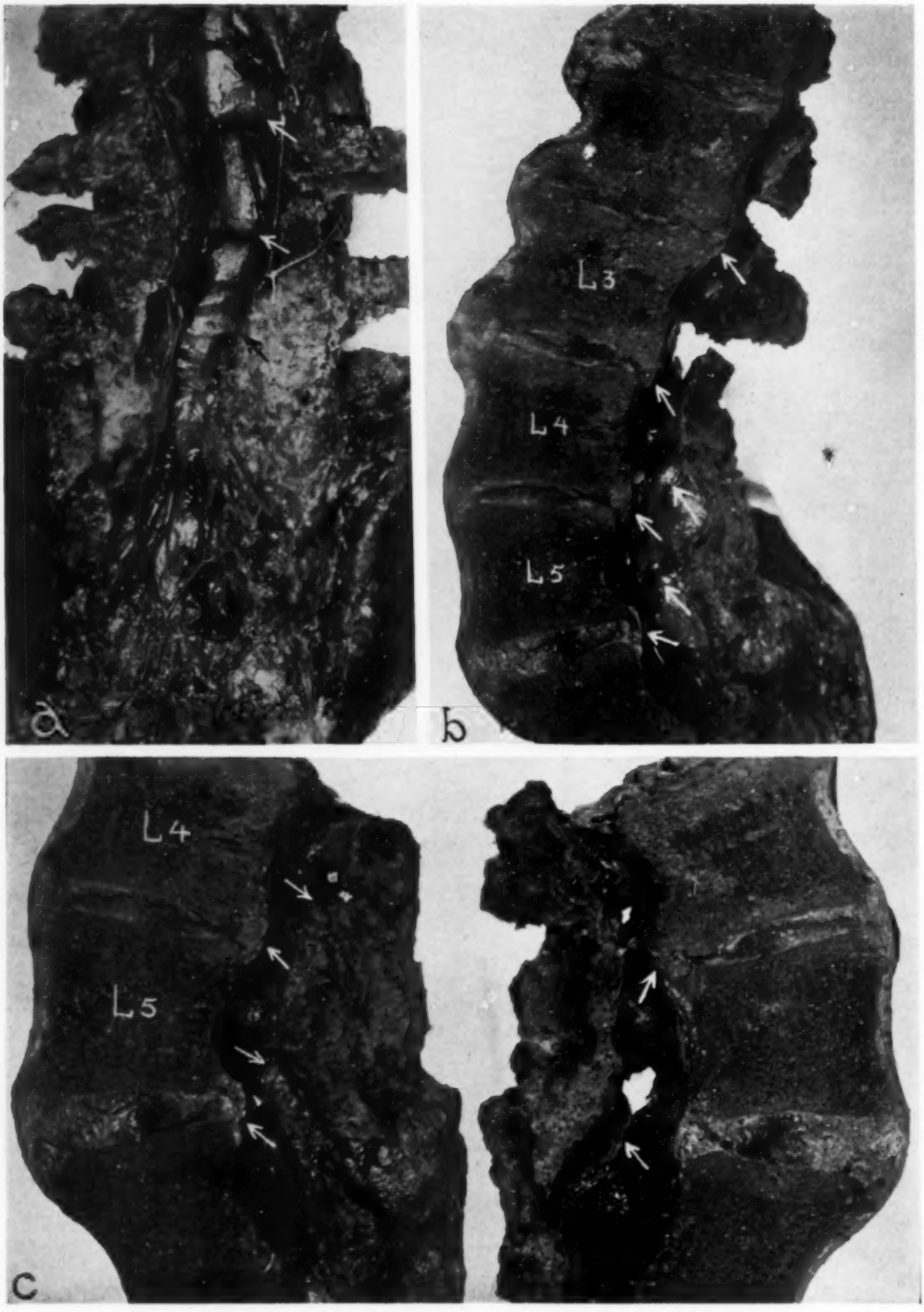

Fig. 7. (*a*) intraspinal view after opening the dural sac posteriorly, and (*b*) right midsagittal section of a lumbar spine with advanced degenerative disease of the vertebrae and the intervertebral discs. In (*c*) the

velopmental in origin, of an enormous dilatation of the caudal sac (Fig. 12). In this specimen, 5 cc. of lipiodol served to fill only the most terminal portion of the sac. In the other variation noted by Camp, the cul-de-sac terminated more proximal than normal, even above the level of the lumbosacral interspace. While shortening of the caudal sac may be simulated on the anteroposterior myelogram, due to the lumbosacral angulation and sacral tilt (see Fig. 1, *c*), the termination at a normal level in this instance will be demonstrated by the lateral myelogram.

The caudal canal was observed, by the writer, to terminate in 58 consecutive cadavers at the following levels:

Just distal to the lumbosacral disc and opposite the 1st sacral body	2
Opposite the intervertebral disc between the 1st and 2nd sacral segments	24
Opposite the 2nd sacral segment	30
Opposite the level between the 2nd and 3rd sacral segments	2

In the presence of any of these three anomalies of the cul-de-sac, the presence of an extradural lesion, in the region of the terminal portion of the caudal canal, could not be accurately ascertained by contrast meylography.

Possible Factors in Positive Myelography in the Presence of Negative Operative Findings. Although explanations for these errors of interpretation, such as that the myelographic defect might have been due to a thickened ligamentum flavum which was removed during laminectomy, or that the operator had failed to locate properly the anatomical site of the suspected disc lesion, are to be considered, these factors were excluded in my cases (Fig. 1). That the defect might have been caused by a "self-reducing" posterior disc protrusion (if such a mechanism occurs) is not acceptable to me in my cases, in view of the fact that no defect was demonstrable, grossly, on inspection of the supposedly involved intervertebral disc, and that the myelographic evidence of a constant defect had been recorded in a position identical to that assumed by the patient during operation, that is, lying upon the abdomen.

Smooth, often multiple, hour-glass contractions, unless constant, are to be evaluated critically, since such phenomena may occur normally as a result of "stringing out" of the contrast medium, when iodized oil is employed (Hampton and Robinson,[12] Robinson[16]). The appearance of multiple protrusions during roentgenoscopic examination with iodized oil is often no more than an exaggeration of the normal prominence of the lumbar intervertebral discs (Bradford and Spurling[2]). Irregular, slow-moving columns will be produced by the extradural or subdural (extra-arachnoid) introduction of this contrast medium. These artefacts, which may lead to faulty interpretation, are not constant on repeated examinations. Such misplacements of iodized oil may follow reduction of spinal fluid pressure, as by lumbar puncture or air spinography (Hamby[10]).

It has been demonstrated in my material that extradural lesions may be produced by degenerative disease involving the intervertebral disc (posterior bulging of the entire disc with underlying hypertrophy of the adjacent bony margins) and the articular facets of the apophyseal joints (bony proliferation of the margins with forward bulging of the overlying ligamentum flavum), and that these lesions may produce defects in the subarachnoid column of contrast medium (Fig. 6). Hampton and Robinson,[12] and Robinson[16] observed that

right and left sagittal sections of the lower lumbar segments and upper sacrum are demonstrated. There are encroachments, anteriorly, on the spinal canal at the level of all of the intervertebral discs, due to posterior bulging of disc substance and posterior marginal proliferation of the adjacent vertebral bodies. The bulges in the posterior portion of the spinal canal, in the region of the ligamentum flavum between the fourth and fifth lumbar and between the fifth lumbar and first sacral vertebrae, which are evident in (*b*), are shown in (*c*) to be due to marginal proliferation of the underlying facets.

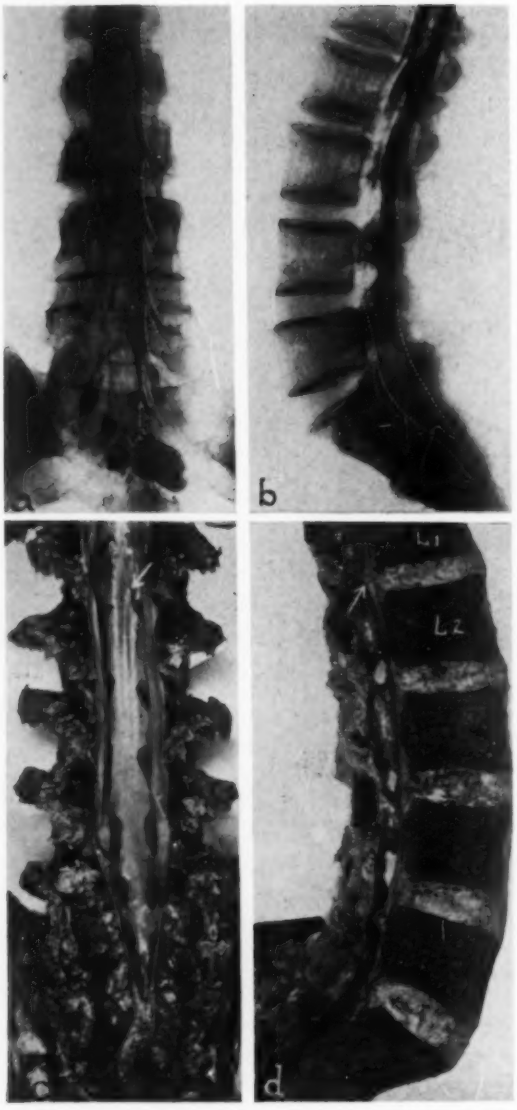

FIG. 8. (*a*) posteroanterior and (*b*) lateral lipiodol myelograms, (*c*) intraspinal view after opening the dural sac posteriorly, and (*d*) midsagittal view of a lumbar spine. No defects in the column of contrast medium are evident in (*a*) and (*b*). In (*c*) there is a central localized projection at the level of the intervertebral disc between the first and second lumbar vertebrae, due, as is shown in (*d*), to posterior protrusion of disc substance. An unusual dilatation of the dural sheaths of some of the terminal roots of the cauda equina is evident in (*a*) and (*c*), which, in the absence of any pathologic process in this region, were interpreted as being developmental in origin.

sharply defined, symmetrical defects on the myelogram at a disc level were sometimes caused by "posterior hypertrophy" of the intervertebral disc as a whole.

A small central posterior disc protrusion may be obscured in all views of the myelographic study by overlying contrast medium (Fig. 8). The question properly

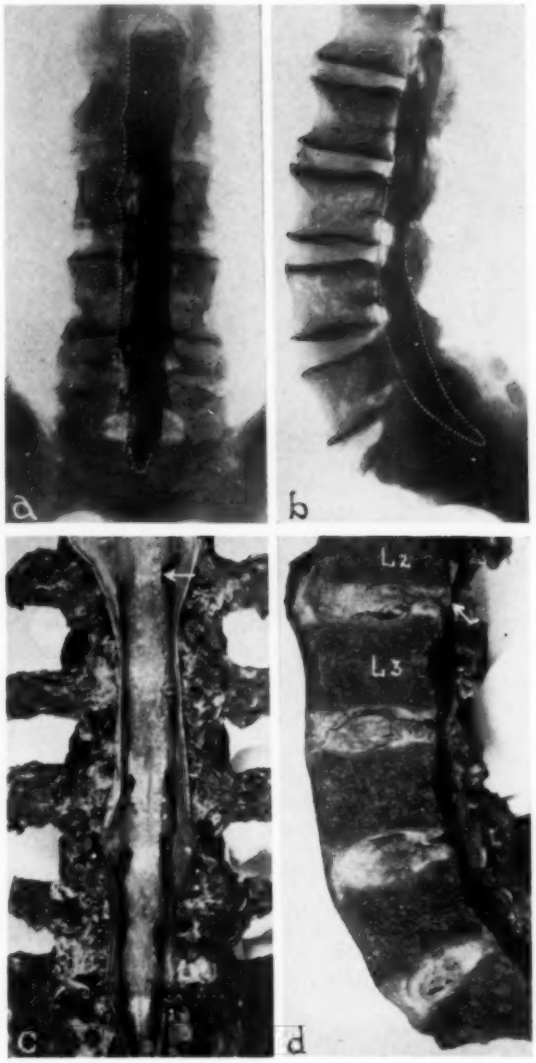

FIG. 9. (*a*) posteroanterior and (*b*) lateral lipiodol myelograms, (*c*) intraspinal view after opening the dural sac posteriorly, and (*d*) midsagittal section of a lumbar spine. No defects are observed in the column of contrast medium in (*a*) and (*b*). In (*c*) and (*d*) there is evident a posterior bulge of the entire width of the disc between the second and third lumbar vertebrae, associated with degeneration of the remainder of the intervertebral disc and marked bony proliferation of the adjacent vertebral bodies.

arises whether such a minimal lesion would be productive of sufficient symptoms and signs to warrant exploration. Dandy[5] has suggested that negative explorations may

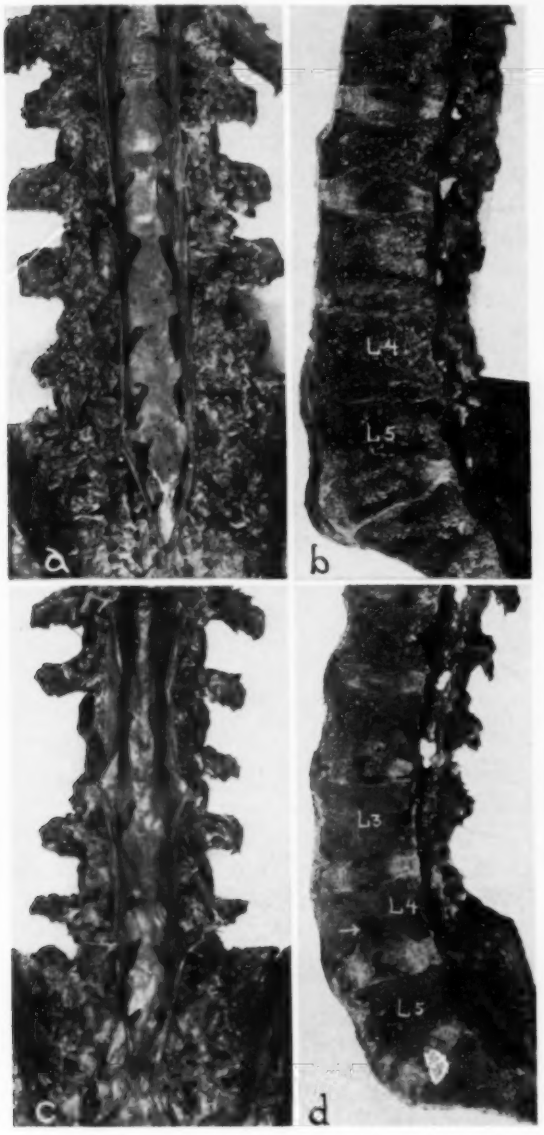

Fig. 10. (*a*) and (*c*) are intraspinal views after opening the dural sac posteriorly, and (*b*) and (*d*) are midsagittal sections of two lumbar spines with advanced degenerative disease of the vertebrae and the intervertebral discs. In (*d*) there is a marked protrusion of the disc between the fourth and fifth lumbar vertebrae into the spongiosa of the fourth lumbar body. There are no distinct encroachments on the spinal canal, despite the presence of advanced degenerative disease in both specimens.

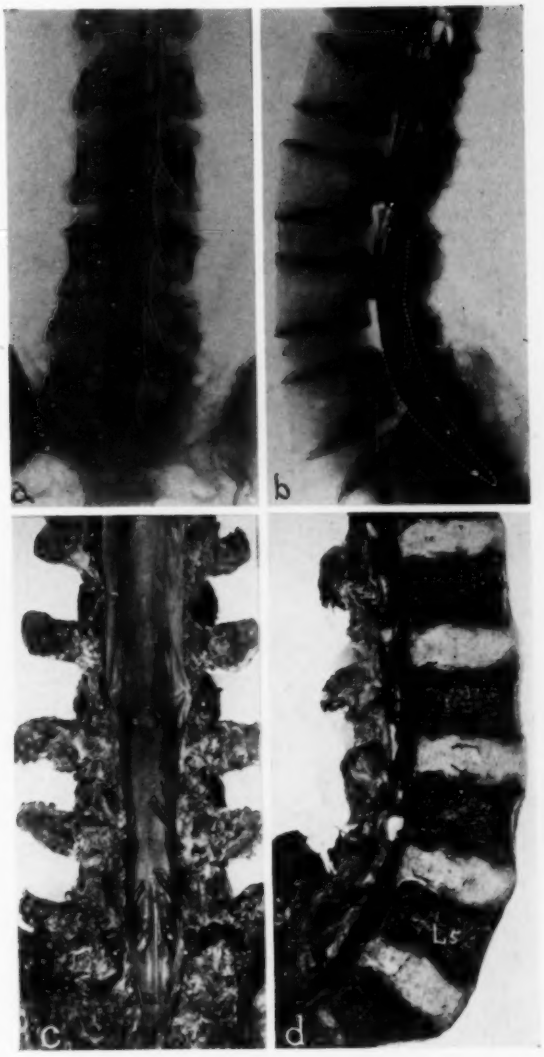

Fig. 11. (*a*) posteroanterior and (*b*) lateral lipiodol myelograms, (*c*) intraspinal view, and (*d*) midsagittal section of a normal lumbar spine.

be due to "concealed ruptured intervertebral disks," in which the posterior protrusions are so slight that they are disclosed at operation only after careful search. It is difficult for me to understand how such lesions which such slight posterior protrusion, especially when these are centrally placed, would produce the symptom-complex of an extradural lesion sufficient to warrant laminectomy. It is my opinion, based on Dandy's description, that the histopathologic features of this lesion are

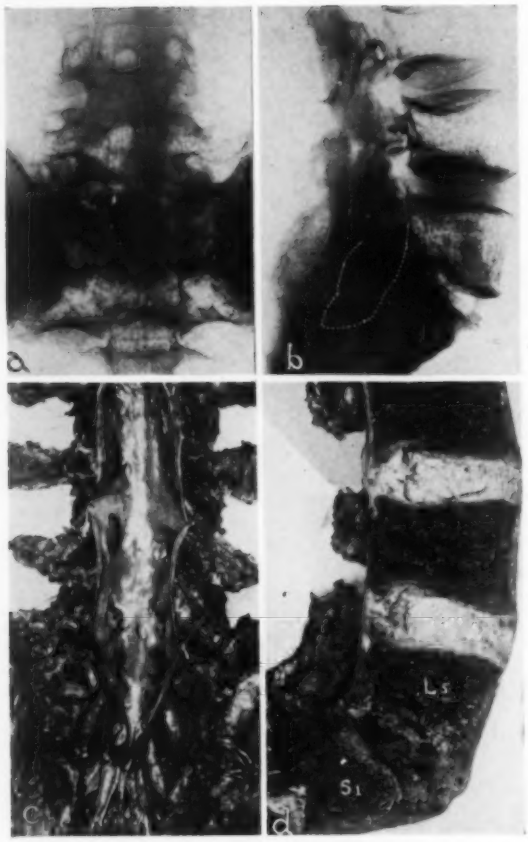

Fig. 12. (*a*) posteroanterior and (*b*) lateral lipiodol myelograms, (*c*) intraspinal view, and (*d*) mid-sagittal section of a lumbar spine, showing an enormous dilatation of the caudal sac, and advanced degenerative disease of the lumbosacral disc, without posterior protrusion of disc substance.

those characteristic of degenerative disease of the intervertebral disc—fibrillation, dehydration, softening, and "brown degeneration" (Horwitz[13]) (Fig. 2, *d;* Fig. 10, *b* and *d;* Fig. 12, *d*). Degenerative disease of the intervertebral disc has been considered a cause of back pain by the orthopedic surgeon, who has treated this lesion by external or internal fixation.

SUMMARY AND CONCLUSIONS

Despite considerable work in this direction, there is need for clarification of a number of problems relating to the diagnosis and treatment of lesions of the intervertebral disc with posterior protrusion into the spinal canal and/or the intervertebral foramen, and to an accurate interpretation of the exact nature of this lesion. The diagnostic criteria are often equivocal. In this respect, the material in this investigation has been evaluated in an effort to illustrate and explain some of the discrepancies in contrast myelography. Most investigators rely on myelography in the diagnosis of this lesion, although there are some who feel that the clinical findings are sufficient for the diagnosis and the localization of this lesion in a high percentage of cases. The interrelation of posterior disc protrusion and other potential factors in the causation of low back pain and the sciatic syndrome, such as degenerative disease of the intervertebral disc, of the vertebrae, and of the zygapophyseal articulations, requires clearer definition. The determination of the best surgical procedure for the treatment of posterior protrusion of the intervertebral disc must await an evaluation of sufficient clinical material, observed over a number of years. The wisdom, at present, of a conservative attitude, is reflected in the conclusions of Bradford and Spurling[2] in their recent monograph on this subject: "Although the presence of a spinal neoplasm is unequivocally an indication for surgical removal where possible, the presence of posterior herniation of the nucleus pulposus is not an indication for surgical removal unless it has produced incapacitating radicular symptoms."

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INTRASPINAL THOROTRAST*

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THE high incidence of protruded intervertebral discs in patients with sciatic pain has stimulated the interest of the orthopedist, the neurological surgeon and the roentgenologist. The accuracy of diagnosis of the protruded intervertebral disc is very high when symptoms and signs are definite. However, there is a considerable number of patients in whom the clinical signs are suggestive of the condition but not sufficiently clear to justify an exploratory operation. It is extremely desirable to have accurate diagnostic information regarding the nature and exact location of the lesion. Although a high degree of accuracy can be obtained in the neurologic diagnosis of intraspinal disease, in some cases confirmatory evidence is needed. For this reason, roentgenologic study of the spinal canal is made with some type of contrast medium. Commonly used media for this purpose are lipiodol, air and, more recently, thorotrast. The choice of a contrast medium, however, should depend upon the amount of information it gives regarding the contours of the subarachnoid space. This agent should also meet the requirements of the ideal intraspinal contrast medium, as set forth by Coe, Otell and Hedley,[1] namely: (1) it should be nontoxic, (2) it should be of sufficient atomic weight to cast a clear-cut shadow, (3) it should be nonirritating, (4) it should be miscible with cerebrospinal fluid, and (5) it should be readily eliminated.

Thorotrast was used first for encephalography by Radovici and Meller[10,11] of France, by Wustmann,[14] and by Löhr and Jacobi[5,6] of Germany in 1932. In 1936 Freeman and his associates,[3,12] and later Twining and Rowbotham[13] recommended its use in ventriculography.

It occurred to me that it might be possible to utilize the desirable properties of thorotrast (its heavy atomic weight, its high specific gravity, and its miscibility with the cerebrospinal fluid) in the visualization of the spinal subarachnoid space, and to eliminate it from the canal by a forced spinal drainage.[4] After a series of animal experiments, with Mortensen,[9] the practicability of this plan was established. The first intraspinal use of thorotrast and its subsequent removal by forced drainage was done clinically by me in 1937.[8] The resulting films showed such promise of being of diagnostic value that further study was made, with the final evolution of the following technique:

Preparation:

1. The patient is prepared for the laminectomy which may follow the myelogram.
2. A sedative is given one hour before myelography.
3 The patient is taken to the roentgen room in a wheel chair.

Myelogram:

1 The patient is put on the tilted roentgen table with the head elevated from 12 to 15 degrees above the horizontal plane.
2. Lumbar puncture is done between the first and second, or second and third lumbar vertebrae; fluid may be taken for analysis if desired, and 10 cc. of thorotrast is injected at an even rate of injection. The needle is then withdrawn.
3. With the patient still in the tilted position, and the head elevated, roentgenoscopy may be done to make certain that the distribution of the medium is correct.
4. Roentgenograms are then made with the patient in the anteroposterior, postero-

* Presented at the Forty-second Annual Meeting, American Roentgen Ray Society, Cincinnati, Ohio, Sept. 23–26, 1941.

anterior, right and left lateral oblique, and the direct lateral positions. Head elevation is maintained throughout. The machine settings usually used for a 150 pound patient are:

	in.	kv.	ma.	Time
Posteroanterior	30	62	40	5 sec.
Anteroposterior	30	65	40	5 sec.
Oblique	30	65	40	5 sec.
Lateral	30	76	40	10 to 12 sec.

5. Upon completion of the roentgenograms the patient is placed in a wheel chair and is returned to bed, the head of which has been elevated to 25 degrees.

After Myelography:

1. The patient is placed on the unaffected side, with the head elevated, and a low lumbar puncture is made with a large bore needle. The puncture is made above the lesion if the canal is obstructed to a marked degree. The fluid is allowed to drain into a sterile flask.

2. With the spinal needle in place, a venoclysis of 750 cc. of 0.45 per cent saline is begun and allowed to empty in one hour.

3. The spinal drainage needle is withdrawn fifteen minutes after the venoclysis is completed.

4. If a surgical lesion is present the patient is then taken to the operating room.

5. The elevation of the back rest is maintained for twenty-four hours.

The properties of thorium dioxide solution (thorotrast) have been published in a report of the Council on Pharmacy and Chemistry.[2] The composition of this medium is given as a stabilized thorium dioxide solution, 25 per cent by volume (19–20 per cent by weight), in a protective colloid (16–19 per cent by weight) of dextrin preparation. A preservative of 0.15 per cent methyl-p-hydroxy benzoate is added to the solution.

The radioactivity of thorotrast has been summarized in the report of the Council as follows:

Alpha ray—25 cc. of thorotrast is equivalent to maximum of 1 microgram and a minimum of 0.5 microgram of radium (Schlundt).

Beta rays—Too feeble to be of physiological significance (Schlundt).

Gamma rays—25 cc. of thorotrast is equivalent to approximately 0.3 microgram of radium (Flinn) and is too feeble to be of physiological significance (Schlundt).

To consider this material in the light of the ideal intraspinal agent, its toxicity must be regarded first. Since the first injections of this material into the subarachnoid spaces in 1932, there have been enthusiastic reports of the subarachnoid detail which was disclosed. There soon followed much less enthusiastic reports because of severe reactions and even deaths after encephalography with this material. The rise in acidity of the cerebrospinal fluid which often accompanied its usage caused a severe reaction. After considerable experimentation the present thorotrast, an alkaline buffered suspension of thorium dioxide in a protective colloid dextrin, was introduced. A slight acidosis of the cerebrospinal fluid may occasionally still occur in some cases, causing a mild reaction, but generally the material is well tolerated There is no real evidence of its toxicity *per se*, just as there is little evidence to show any real toxicity attributable to the other commonly used mediums.

Retention of thorotrast in the subarachnoid space will result in an aseptic meningeal reaction. However, it is common knowledge that the intraspinal injection of any foreign substance will produce a meningeal reaction proportionate to the irritating effect of the material injected. For this reason, it was felt advisable to remove any contrast medium from the subarachnoid space after it had served its purpose.

The clarity with which the intraspinal structures are visualized with thorotrast is due to the high molecular weight of the particles in suspension. The fact that the heavy thorium dioxide particles are in suspension makes possible the outlining of small fluid-displacing lesions either in the canal or compressing it from outside. In the suggested concentrations the shadow cast

is not heavy enough to mask an underlying lesion, nor is it so faint as to leave the diagnosis uncertain.

The irritating qualities of thorotrast are largely dependent upon the dextrin concentration and the small amount of preservative it contains. The thorium dioxide particles are chemically inactive and contribute to its irritative properties only their presence as foreign bodies of microscopic size. This is unlike the irritating effects of certain iodized solutions and oils which have as their chief source of irritation the liberation of varied amounts of iodine into the surrounding medium. The irritating effects of subarachnoidally placed iodides is well known.

Fig. 1. Normal thorotrast myelogram. The nerve roots and their dural sleeves are demonstrated (oblique view).

Thorotrast possesses the property of miscibility with the cerebrospinal fluid. It is a golden-brown, opalescent fluid of watery consistency whose specific gravity is greater than that of spinal fluid. For this reason the distribution of the medium in the spinal canal can be controlled reasonably well by placing the patient at such angles as to keep the medium at the examination site. It is the property of miscibility with the cerebrospinal fluid that gives thorotrast its chief advantage over other contrast media.

The subarachnoid outline is accurately seen wherever the spinal fluid can penetrate with its contained thorotrast. Consequently, in the area to be examined, the entire width of the spinal canal, the spinal roots in their intraspinal course, together with their dural sleeves are seen in their normal relations (Fig. 1). There is no disturbance of the cerebrospinal fluid dynamics by the withdrawal of a large amount of fluid with a subsequent alteration in the anatomic relations. There is not the problem of a medium with a surface tension so much greater than that of the cerebrospinal fluid that its tendency to assume its smallest form may frustrate the examiner. By breaking up into coarse globules, an oily medium can nullify the usefulness of the examination. Because of the high surface tension of the oily contrast mass, it is not always possible to make the media outline the finer detail of the subarachnoid space. In the larger lesions encroaching upon the spinal canal, the choice of a contrast medium is hardly a serious consideration, since the problem is usually a simple one for the clinician and the roentgenologist. However, it is in that lesion which has caused as yet but little change in the anatomic relations in the spinal canal that thorotrast has its greatest usefulness by its ability to depict with greater accuracy the relative minutiae of the subarachnoid space.

It is highly desirable to remove from the spinal subarachnoid spaces any contrast medium which is not normally absorbed. An oily medium may be partly removed by aspiration under the roentgenoscope or at operation. By virtue of its miscibility with cerebrospinal fluid, from 70 to 95 per cent of an injected thorotrast solution can be recovered by instituting a forced spinal

drainage as previously described after the roentgen studies have been made. It is desirable to remove the thorotrast from the canal because of the low grade radioactivity. In a previous publication,[7] a summary of the radioactivity present in an average case was given. In this case 8 cc. of thorotrast was used and 80 per cent was recovered. It was calculated that the residual of radioactive material dispersed by the reticulo-endothelial cells of the meninges was equivalent in alpha radiation to 0.064 microgram of radium, and in gamma radiation to 0.0256 microgram of radium. It is obvious that this amount is far below any described minimal toxic level, which is a margin of safety considerably greater than many other substances used clinically.

In summarizing the first 100 myelograms in which thorotrast was used at the Cleveland Clinic, Table 1 is presented:

TABLE I

I. No. of cases	100
II. No. of protruded intervertebral discs	62
Miscellaneous lesions	17
Negative myelograms	21
III. Sex	
Males	77
Females	23
IV. Age incidence	
10–20 years	2
21–30 years	12
31–40 years	41
41–50 years	24
51–60 years	19
61–70 years	2
V. Clinical diagnosis made before myelography	
Protruded intervertebral disc	58
Suspected protrusion of intervertebral disc	36
Miscellaneous lesions (mechanical back strain, functional conditions, radiculitis, hip-joint disease)	6
VI. Diagnosis made from myelogram	
Positive for protruded intervertebral disc	66
Positive for other lesions	3
Questionable protrusion of disc	4
Definitely negative myelogram	26
Injected outside canal accidentally	1
VII. Operative findings. Total of 75 operations done; 25 not operated upon	
Protruded intervertebral disc found	62
Miscellaneous lesions	7
Negative explorations	6
VIII. Total of 75 laminectomies done with	
a. 66 (positive or suspected) cases with a diagnosis of protruded intervertebral disc, of which 62 were correct at operation and 4 were incorrect. Of the 4 cases in which the myelogram was suggestive of a lesion and judged erroneous at operation, 2 cases had a prominence of a disc probably not responsible for symptoms, and in 2 there was no pathologic condition.	
b. 9 patients with a negative myelogram were operated upon with only one protrusion of the intervertebral disc found.	
IX. a. In the positive myelograms confirmed by operation the diagnostic accuracy of thorotrast is 93.97 per cent (error of 6.17 per cent).	
b. In the negative myelograms which were explored on clinical grounds alone, the diagnostic accuracy of thorotrast was 89.97 per cent, the error 11.1 per cent.	

The search for the ideal intraspinal contrast medium is not ended. By instituting the technique described here, we have eliminated most of the undesirable features of thorotrast. A medium has not yet been found which will outline every structure within the subarachnoid space, sharply define its every ramification, and then be spontaneously absorbed and eliminated after it has served its purpose.

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PYOGENIC OSTEOMYELITIS OF THE THORACIC SPINE PRESENTING AS PRIMARY PULMONARY DISEASE*

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DURING the past decade it has become increasingly apparent that osteomyelitis of the spine is an extremely protean disease which may offer great difficulty in early diagnosis. Various manifestations and presentations of these vertebral infections have been described in the literature. The majority of these reports are concerned with the abdominal symptomatology associated with osteomyelitis of the lumbar vertebrae. Cases with symptoms referable to the dorsal region have been published less frequently.[2,5,6,8,10] Reports of thoracic spine osteomyelitis completely masquerading as a primary pulmonary infection have appeared only rarely.

Pyogenic osteomyelitis of the vertebrae has been described in considerable detail by Wilensky[10] and Kulowski.[6] The disease is almost always of hematogenous origin and tends to involve the lumbar region much more frequently than the thoracic spine. Difference of opinion is held concerning the sites of localization of the infection in the dorsal vertebrae. Thus, Wilensky states that the posterior portions of the vertebrae are involved more frequently than the bodies. Kulowski, however, believes that the bodies and adjacent intervertebral discs are affected most often. In 102 cases involving all regions of the spine he found the bodies involved in 84 instances, the posterior processes in 13 and combined lesions in 5 cases. Many reports of single cases have appeared illustrating both types of infections.

The symptomatology of thoracic vertebral osteomyelitis appears directly influenced by the location of the lesion since the latter determines in which direction the pus will migrate. Involvement of the spinous processes, posterior portions of the pedicles and posterior surfaces of the transverse processes usually results in deeply situated abscesses in the posterior thoracic muscles which finally point at the back of the chest. Infrequently, the suppuration extends internally and results in the formation of an epidural abscess.[1] Localization of the lesion in the anterior part of the pedicles and anterior surface of the lateral thoracic processes is soon followed by a purulent infection in the mediastinum, paravertebral and posterior extrapleural spaces. Osteomyelitis of the vertebral body and adjacent disc is almost invariably complicated by mediastinal abscess. In turn, the mediastinal abscess may spread by direct contiguity, or via the lymphatic channels, and cause an empyema or suppurative pericarditis. Many combinations and variations of these patterns have occurred and have given rise to extremely complex syndromes.

The signs and symptoms of a given case may often be misleading, at least during the early stages of the disease. With involvement of the posterior vertebral processes the high fever, rigidity and fixation of the back muscles, excruciating tenderness over the involved vertebra and superficial pointing of the burrowing abscess at the dorsum

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of the chest wall usually make the diagnosis apparent after a comparatively short interval. Rarely, in cases of epidural abscess or collapse of a vertebral body, evidence of spinal cord compression is present. Infection of the bodies and intervertebral discs, however, results in a mediastinitis or extrapleural abscess and their complicating empyema or suppurative pericarditis. In these patients the chief complaints and findings are related to the respiratory system, making the proper diagnosis extremely difficult. Superficial pointing of the abscess may occur very late in the course or not at all, and the changes in the spine may be completely masked by the pulmonary syndrome. Thus, in Kulowski's series of 102 cases, mistaken diagnoses were made in 7; 4 cases being originally interpreted as pneumonia and empyema, while 3 patients were originally considered to have cancer of the mediastinum. Hahn[4] reports a case diagnosed and treated in its early stages as pneumonia. Makins and Abbott[7] and Wilensky[10] describe cases in which the true nature of the malady was not appreciated until the postmortem examination.

Roentgenographic examination is extremely important in the diagnosis of pyogenic osteomyelitis of the dorsal spine. The changes encountered are of two types: those confined to the vertebrae themselves and those related to the complications. It is essential that the roentgenograms of the spine have fine bony detail. Oblique views may often be of aid where lesions of the posterior articulating facets are suspected.

During the initial weeks of the disease roentgen evidence of pathological changes in the vertebrae may be entirely lacking.[3,9] One of the early and important roentgenographic signs, and meriting careful search, is destruction of the disc with narrowing of the intervertebral space.[3,6] Changes in trabecular structure occur shortly thereafter. Following these appear the characteristic, dense, reactive new bone formation which results in markedly increased bone density, exostoses and bony bridges. These findings may be associated with mottling, erosion, sequestration, destruction, wedging and collapse due to the destructive effects of the infective process. It is this combination of destruction with dense new bone deposits, exostoses and bridging which characterizes pyogenic osteomyelitis and differentiates it from vertebral tuberculosis. The marked bony atrophy and decalcification observed during the active, early phases of tuberculous spondylitis is almost never seen at any stage of pyogenic osteomyelitis.

Paravertebral mediastinal abscess and suppurative mediastinitis are the most frequent and important complications of osteomyelitis in the dorsal spine. Roentgenographic changes appear early and are characterized by widening of the mediastinum to the right, left or bilaterally. The border of the widened mediastinum is sharply demarcated from the adjacent lung tissue, forming an almost straight or very slightly curved line of separation.[1,2,6,10] The appearance may often be distinguished with ease from the semilunar, arc-like shadows cast by greatly enlarged mediastinal lymph glands. As the infection spreads, mediastinal widening continues and areas of adjacent pneumonitis may appear. Should empyema supervene, the roentgenograms[5] reveal the typical picture of such a condition. Retropleural infections may cast bizarre shadows on the roentgen film, depending upon the shape and position of the localized, peripheral empyemata. Serial roentgenograms are extremely important in accurately following the course, possible spreads and sequelae of the osteomyelitic process.

CASE REPORT

L. R., a white male, aged thirty-three, was admitted to Bellevue Hospital on July 17, 1939. The patient had been in excellent health until February, 1939, at which time cough, expectoration of foul, blood-tinged sputum, pain in the chest, weakness, night sweats, anorexia and loss of weight appeared rather suddenly. The symptoms gradually became worse, weight loss increased, occasional pain was noted in the back of the chest, asthenia became marked and

the patient sought medical aid at the Beth David Hospital, New York City, in May, 1939.

Physical findings on admission to that institution revealed dullness, diminished breath sounds and râles in the left lower portion of the thorax posteriorly. Roentgenograms of the chest (Fig. 1) revealed a large dense shadow in the left mid-lung field, interpreted as a consolidation. A small, sharply demarcated, triangular opacity at the root of the right lung was not thought significant. The patient constantly coughed throughout his entire stay and had a septic, spiking fever. Wassermann and Kline tests were negative. Repeated examination of the sputum failed to demonstrate tubercle bacilli. Roentgenograms of the dorsal and lumbar spine were reported as negative. Roentgenograms of the sinuses showed a bilateral maxillary antral clouding. Bronchoscopy yielded no positive information. Bronchographic examination was reported as showing saccular and cylindrical dilatation of the bronchi in the lower portion of the left upper lobe. While in the hospital the patient received sulfapyridine and symptomatic treatment, including one 500 cc. transfusion. During his stay at Beth David Hospital the cough and physical findings improved only slightly. Serial roentgenograms of the chest were reported as showing no definite change in the lung findings. There was no evidence of a fluid level or lung abscess. Pain in the chest continued unabated; that in the back of the chest was medial in location and apparently was unaffected by respiration. The remittent fever continued, but the levels were somewhat lower than on admission. Further hospital care and observation were deemed necessary and the patient was therefore transferred to Bellevue Hospital with the provisional diagnosis of left upper lobe bronchiectasis.

The patient's past history included an attack of croup in childhood and a mild chronic cough distinctly different from that accompanying the present illness. There were no operations or accidents. He has had carious teeth for many years. The family history was negative for tuberculosis, allergic phenomena or cancer. The patient's mother suffered from diabetes mellitus and died at the age of sixty-two.

Admission examination on July 17, 1939, revealed a poorly nourished male appearing chronically ill. Temperature 102.4° F., respiratory rate 28, pulse 96, blood pressure 120/70. Head: eyes reacted equally to light and in accommodation; the throat was chronically infected; lower jaw edentulous, several upper teeth carious; the gums were inflamed. Neck: no glands or masses; trachea in midline. Chest: symmetrical; percussion dullness on left side posteriorly from T_4 to T_8; bronchial and bronchovesicular breath sounds as well as numerous moist and coarse râles present in this region; the base appeared clear. Moist, crackling râles were also heard in the left anterior axillary region. On the right side moderate dullness was present in the paravertebral region at the level of the scapula. The heart was normal in size; sounds were of fair quality; regular sinus rhythm, rate 96 per minute; no murmurs. Abdomen: liver and spleen not palpable; no masses. Extremities: normal; no clubbing of the fingers. Reflexes: normal.

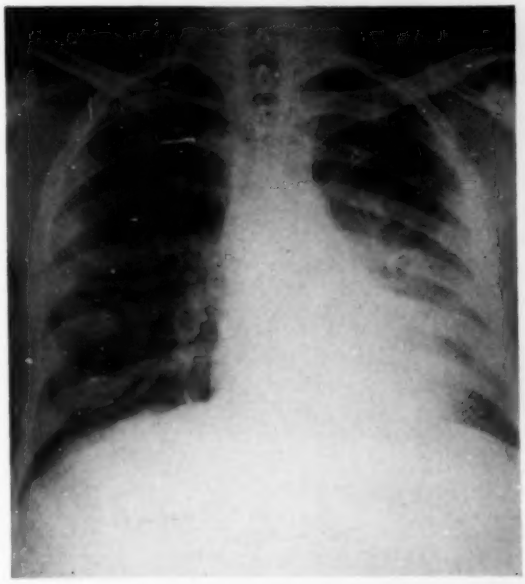

Fig. 1. Large dense shadow in the left mid-lung field. Note the small, triangular opacity at the root of the right lung.

Roentgenoscopy of the chest revealed a marked increase in density in the lower half of the left lung field just above a clear costophrenic sinus. The right lung was clear, but there was a marked increase in the density of the right hilar shadows. This density measured 6 by 10 cm. and presented a somewhat irregular outline.

Admission laboratory examination revealed the urine to be entirely normal. Blood count: hemoglobin 56 per cent; red blood cells

4,230,000; white blood cells 6,900; differential smear showed 77 per cent polymorphonuclear leukocytes, 23 per cent lymphocytes. Wassermann reaction was negative. Erythrocyte sedimentation rate was 138 mm. in one hour.

FIG. 2. Anteroposterior and lateral views. Irregular destruction and collapse of bodies of fourth, fifth, sixth and seventh thoracic vertebrae.

Roentgenographic examination of the chest was reported as showing a large patch of unresolved consolidation involving the left upper lobe medially and posteriorly. There was dense perihilar fibrosis and thickening of the mid-third of the axillary pleura on the left side. Blood sugar 114 mg. per 100 cc.; non-protein nitrogen 30 mg. per 100 cc. Sputum analysis showed no acid-fast bacilli. Electrocardiogram revealed some notching of the R waves in lead 3 and left axis deviation, but otherwise was normal.

Admission diagnoses varied between bronchiectasis, resolving pneumonia, tuberculosis and pulmonary neoplasm.

Course: The patient continued to run an intermittent fever with temperatures varying from 99° F. in the forenoon to 103° F. in the afternoon. Repeated sputum analyses were negative for acid-fast bacilli and an intradermal injection of 0.1 mg. of Old Tuberculin caused no reaction. Coughing continued and there was frequent expectoration of bloody mucoid sputum. Re-examination of the chest by roentgen ray now demonstrated a sharply bordered, marked density immediately lateral to the root of the right lung and extending from the clavicle to the lower hilum. This was suggestive of a mediastinal tumor. The moderately dense, diffuse shadow was again observed in the left midlung field. On July 29, 1939, the patient suddenly expectorated 50 cc. of bright red blood, lost consciousness and showed clonic convulsions of the left leg. He was treated for shock and gradually recovered from the acute episode. Bronchoscopy was performed on August 2, 1939, but the examination was not entirely satisfactory. Mucopurulent material was present in the right main bronchus from which a biopsy was taken. There was no evidence of tumor. The septic course continued, the spleen became palpable and severe interscapular pain gradually made its appearance. Repeated urine analyses revealed no abnormality. Blood counts showed no leukocytosis, but the erythrocytes dropped to 3,850,000 and the hemoglobin gradually diminished to 58 per cent. Additional investigation of the sputum consistently failed to reveal tubercle bacilli. A sputum culture resulted in the growth of *Streptococcus viridans*, *Staphylococcus aureus* and fusiform bacilli.

The severe interscapular pain over the dorsal vertebrae gradually increased and tenderness over the spine in this region was elicited. On August 10, 1939, one month after admission, definite weakness and atrophy of the peripheral muscles, especially the interossei, of the right upper extremity were observed. Beginning atrophy of the left interossei also appeared. Other neurological findings were absent. Diagnostic spinal puncture showed the following: initial pressure 120 mm.; the fluid was clear

and contained 2 cells per cubic millimeter; globulin, trace; Wassermann reaction, negative.

The patient continued to bring up between 5 and 15 cc. of bright red blood at frequent intervals and bronchoscopy was repeated. Biopsy again showed only normal tissue. Repeated roentgen examination of the chest demonstrated a gradual increase in the size of the density in the right superior mediastinal region. There was suggestive evidence of pneumonitis in both lungs as well as a possible atelectasis in the right upper lobe. Roentgenograms of the thoracic spine were at this time reported as normal. Another bronchoscopic examination showed no evidence of tumor, but mucopurulent material was seen in the right main bronchus. A blood count performed on August 8, 1939, showed 12,200 white blood cells, of which 88 per cent were polymorphonuclear leukocytes and 12 per cent lymphocytes. The red blood cells had fallen to 3,450,000 and the hemoglobin was 70 per cent (Sahli).

Repeated consultations with the Chest Service resulted in the impression that the mediastinal mass might be a malignant lymphoblastoma. Accordingly, a therapeutic test with deep radiation therapy was given to the right anterior mediastinum. The factors employed were: 200 kv., 20 ma., 0.5 mm. copper and 1.0 mm. aluminum filtration, 50 cm. target-skin distance and a field size of 10 by 15 cm.; 1,000 r was delivered to this skin portal in ten days. No demonstrable improvement or reduction in the size of the mass was observed. Severe interscapular pain, cough with hemoptysis and spiking temperature continued.

On September 16, 1939, two days following the last roentgen treatment and two months after admission, there appeared a fluctuant swelling to the right of the spine at the level of the third to sixth dorsal vertebrae. On aspiration of the region 30 cc. of foul, greenish pus was obtained. Culture resulted in the growth and identification of *B. coli* and *B. lactis aerogenes*. Roentgenograms (Fig. 2) of the thoracic spine on September 25, 1939, revealed for the first time irregular destructive changes in the bodies of the fourth, fifth, sixth and seventh thoracic vertebrae. A roentgenogram of the chest showed a marked widening of the superior mediastinum, particularly on the right, with areas of surrounding pulmonary infiltration (Fig. 3).

The abscess over the dorsal spine gradually increased in size and was accompanied by the expectoration of an increasing amount of purulent sputum. Incision and drainage was performed on September 29, 1939. A large amount of foul pus was withdrawn, revealing a sinus which connected with the diseased, necrotic spinous processes of the third and fourth thoracic vertebrae. Air was observed in the abscess cavity upon opening. Pus and blood were also seen to drain out of the trachea into the pharynx, indicating a connection of the mediastinal abscess with a major airway. Further exploration revealed the sinus to extend across the bodies of the involved vertebrae to the left side of the chest. From this latter region large amounts of pus drained, the drainage increasing with cough. No further procedure was attempted at this time because of the patient's poor condition, and the wound was packed.

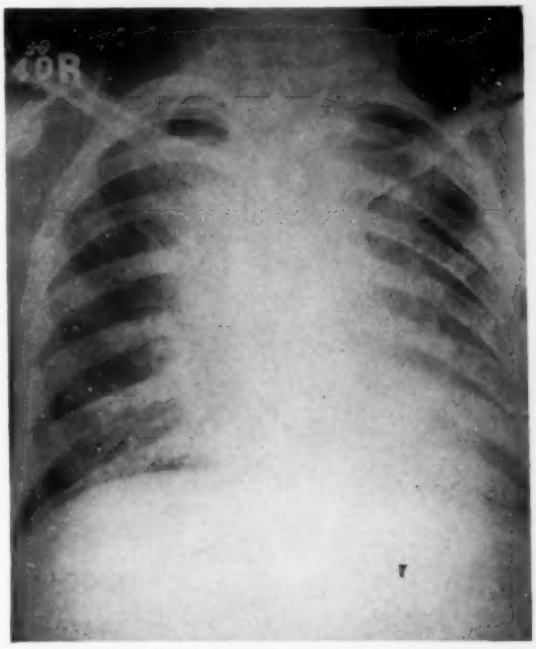

Fig. 3. Marked widening of the superior mediastinum, especially on the right, with areas of surrounding pneumonitis.

Following operation there was moderate improvement in the patient's general condition. It soon became apparent, however, that drainage was inadequate. Accordingly, a second incision and drainage was performed on October 5, 1939, in the left posterior mediastinal region. The heads of the third and fourth ribs were

resected, exposing a large cavity with a moderate amount of pus. Exploration was accompanied by shock and further procedure was therefore impossible. Postoperative drainage was only moderate and roentgenograms showed the presence of a pyopneumothorax on the left side with drainage tubes in situ at the operative site. Despite supportive therapy the patient's course grew gradually worse and he died on October 25, 1939, about nine months after the appearance of symptoms.

Postmortem examination revealed the following pertinent data:

Gross findings: The body was that of a white male, poorly developed and poorly nourished. In the upper portion of the right chest posteriorly was a 3 inch gaping incision. On the left side a 3 inch vertical, interscapular incision was present. There was no external edema, cyanosis or clubbing of the fingers or toes. Some atrophy of the lumbrical muscles of the right hand was observed.

On opening the chest, the left lung was found markedly reduced in size. The pleura over its entire periphery was considerably thickened, and multiple, dense, fibrotic adhesions were present. A well encapsulated, intrapleural empyema was seen at the apex of the upper lobe which connected with the left sinus draining posteriorly. This empyema cavity extended forward to the anterior chest wall. The lung could not be removed except with considerable difficulty and tearing of the tissues because of the thick adhesions. The right lung had very few adhesions, was large, emphysematous and crepitant. There was no noticeable shift in the position of the heart.

The left lung when removed was found to be much smaller than normal. Its exterior was rough and shaggy because of the tearing during removal. The bronchi were found to contain a considerable amount of clotted blood. No bronchopleural fistula could be demonstrated, possibly because of the destruction of the tissues in removing the organ. On section, the parenchyma was quite firm and compact in appearance. The pulmonary vessels were found to be patent and a definite point of hemorrhage could not be located.

The right lung was found to be quite large, crepitant and emphysematous throughout. Sections showed the tissue to be spongy in appearance. The large bronchi and the right pulmonary vessels were patent.

Upon the removal of the lungs and heart an old inflammatory process in the paravertebral tissues was found at approximately the level of the first to the seventh upper dorsal vertebrae and ribs. This was somewhat more marked on the right than on the left.

The heart, aorta, gastrointestinal tract, kidneys, adrenals, pancreas and lymph node systems all showed no abnormality.

The spleen weighed 300 grams. Its capsule was thin and tense, and the underlying parenchyma was a dirty slate-gray color. On section it cut readily. The cut surface was smooth, moderately friable and the pulp abundant.

The liver weighed 2,100 grams. There was mild congestion of the liver parenchyma. Otherwise, no noteworthy changes were observed either in this viscus or the gall bladder.

Microscopic findings: Sections through the vertebrae, ribs and paravertebral tissues revealed marked granulation tissue reaction with infiltration of many lymphocytes. There was fragmentation of bone with some focal collections of polymorphonuclear leukocytes and lymphocytes. The inflammatory mass in the right and left paravertebral area showed the findings of chronic inflammation: much granulation tissue, many lymphocytes and polymorphonuclear leukocytes. In one section was seen a spicule of bone. There was no evidence of new growth.

Slides of the right lung revealed the cells lining the acini to be edematous and the capillaries engorged. Within the lumina of many of the acini were numerous, large, pink mononuclear leukocytes, the so-called "heart failure" cells. Sections through the left lung showed a pulmonary consolidation, the lumina of most of the acini being compressed or occluded, with an almost complete loss of architecture. Many "heart failure" cells were also present in this section. Red blood cells were seen in the bronchi.

The spleen on section revealed its venous sinusoids to be particularly prominent and the pulp abundant. The liver showed changes of marked, chronic, passive congestion. All of the vessels were dilated. The venous sinusoids were very prominent, resulting in pressure on the liver cord cells.

Sections through the heart, kidneys and prostate demonstrated no noteworthy abnormalities.

Anatomic diagnoses: (1) acute and chronic

osteomyelitis with necrosis of the dorsal vertebrae, first to seventh, and adjacent ribs; (2) chronic mediastinitis with right paravertebral abscess; (3) encapsulated chronic empyema posterior to the apex of the left lung and abscess in the adjacent posterior mediastinum; (4) left parietal chronic pleurisy with multiple, peripheral, fibrotic adhesions; (5) atelectasis of the left lung. Compensatory emphysema of right lung; (6) left bronchopleural fistula; (7) antemortem clot in left main bronchus; (8) slight atrophy of lumbrical muscles of the right hand; (9) mild toxic splenitis; (10) chronic passive congestion of the liver.

COMMENT

From the onset and throughout the seven months of hospitalization the clinical findings suggested a tentative diagnosis of primary inflammatory disease of the lungs. The constant manifestations were pain in the chest, severe cough, profuse expectoration, frequent and severe hemoptysis, dyspnea and sepsis. Roentgenographic examination supported such an opinion since vertebral abnormalities were not seen until late in the course. The early roentgenographic changes were related only to the pulmonary pathology. Thus, reports from the Beth David Hospital mentioned only a diffuse density in the lower part of the left upper lobe and evidence of mediastinitis was not noted.

Because of the profuse purulent expectoration, hemoptysis and suggestive roentgen findings bronchiectasis could be inferred. In the absence of other causes, the possibility of an infected bronchial ectasia resulting from a previously expelled foreign body necessitated consideration. Bronchography and repeated bronchoscopies were therefore performed. Tuberculosis and other specific infections of the lung or bronchus were excluded by roentgen examinations, bronchoscopic and sputum studies. Evidence for abscess or necrosis of the lung was likewise lacking.

Mediastinitis on the right side became definitely apparent on the roentgenograms of the chest taken shortly after the patient's admission to Bellevue Hospital, five months after onset of illness. However, because of the extensive opacity in the left lung field it was not considered likely that all of the chest involvement could arise from a vertebral osteomyelitis. Such a view was apparently supported when roentgenograms of the dorsal spine made at about the same time were described as showing no evidence of disease.

As the mediastinal abscess enlarged the nodular outline of the widened root shadow grew large, lost its sharp delineation from the surrounding lung tissue and suggested the diagnosis of mediastinal lymphoma. The presence of a palpable spleen appeared to confirm this diagnosis, and the destructive vertebral changes which appeared later were ascribed to bony extension of the lymphoma. Deep roentgen therapy of the abscess which was mistaken for lymphoma was soon followed by pointing of the mediastinal suppuration with paravertebral abscess formation and accentuation of the septic state.

The bilateral brachial plexus nerve root signs due to pressure associated with the diseased vertebrae, and indicated by weakness of the arms and atrophy of the small muscles of the hand, developed late in the course of the illness. However, a noteworthy manifestation of vertebral involvement which was present from the onset was the fixed, supine position which the patient constantly assumed. Always bedfast during his entire hospitalization period he would not raise his body even to control a severe coughing spell or expectorate, and would eat his meals lying flat in bed.

Roentgen evidence of osteomyelitis with destruction of the dorsal vertebrae finally became apparent seven months after the onset of symptoms, concomitantly with the superficial pointing of the abscess. By this time the vertebrae were completely riddled with the pyogenic infection and the disease had become far advanced.

At autopsy the destruction of the dorsal vertebrae by pyogenic osteomyelitis was very extensive, and the other changes were essentially those of suppurative mediastin-

itis. No gross bleeding areas in the bronchi were found to explain the severe and frequent hemoptyses which apparently were due to congestive changes alone.

SUMMARY

In the developing clinical picture of pyogenic osteomyelitis of the spine, the paravertebral complications, local or distant, may commonly appear as the primary condition while destruction of the spine may progress extensively and, unfortunately, remain unrecognized. Any case with high fever, pain in the back over the spine and roentgenographic evidence of mediastinal widening (mediastinitis) should have the possibility of pyogenic dorsal vertebral osteomyelitis excluded regardless of other pulmonary signs, symptoms or roentgenographic appearances and despite the failure to demonstrate changes in the vertebrae on the roentgenograms.

In conclusion, the clinical, pathological and roentgenographic features of this condition are discussed and an illustrative case with autopsy findings reported.

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THE THERAPEUTIC VALUE OF ROENTGEN TREATMENT IN CHRONIC ASTHMA

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THE treatment of asthma by radiation was probably first observed by Schilling in 1906, following prolonged roentgenoscopic examination of an asthmatic sufferer. Treatment by irradiation of the chest was later advocated in 1926 by Scott[10] in London, who reported favorable results in 21 cases of chronic asthma. He discovered that easier breathing frequently followed irradiation of breast carcinoma which suggested to him the possibility of roentgen therapy for the relief of asthma. Beneficial results have been reported from time to time from radiation treatment to various parts of the body, particularly the spleen, liver, pituitary gland, long bones, and other regions.

Scott's interest in the treatment of asthma by radiation stimulated a more systematic investigation of the asthmatic problem by selecting patients who were definitely asthmatic sufferers and free of other complications, particularly breast carcinoma. He used low voltage and emphasized the importance of exposing large fields of the entire trunk to irradiation. He believed that relief was obtained in practically every case treated, and noticed that within twenty-four hours there was usually an increase in the amount of mucus expectorated from the bronchial tubes.

In 1929 Scott[11] reported a series of 121 cases of asthma treated by radiation in which 89 obtained definite benefit. He pointed out the importance of careful roentgenological examination of the chest in all cases previous to treatment. He remarks that a definite fibrosis at the roots of the lungs is present in practically all asthmatics, which he believes to be a secondary condition since no changes were detected even after irradiation had been successful. The majority of his cases had used the numerous remedies and methods of treating asthma, including cigarette smoke, adrenalin products, medicated inhalers, etc., and were in nearly every instance in desperate circumstances.

Probably the first systematic treatment of asthma by radiation in this country was applied at the Mayo Clinic by Maytum and Leddy[5,6] between the years 1931 and 1934. In the original report of some 23 patients, 5 were markedly relieved for many months, while 8 obtained marked relief for shorter periods. In 1939 Maytum and Leddy[7] reported another series, comprising 215 patients, which they treated between 1935 and 1938. Twenty-four per cent of this group obtained more than 75 per cent relief which lasted from one to four years. A large part of this group (161 cases) received no other treatment. Twenty-three patients, or 14 per cent, received as much relief, but in addition to the roentgen therapy were put on the regular treatment for asthma.

Observations on the treatment of our first series of 100 consecutive cases over a six months' period, focused our attention unexpectedly upon the importance of infection in the asthmatic problem. Due to the superior results from the roentgen therapy in those infected cases, the selection of the 1,500 patients treated since has been made easier.

Although a number of investigators have used roentgen therapy in the treatment of asthma, none have considered fully the importance of infected accessory nasal sinuses as an etiological and aggravating factor in severe cases. The majority of our patients who received roentgen therapy to the chest, also received radiation therapy to the accessory sinuses whenever they were found involved. We regard routine roentgenograms of the chest and sinuses in all asthmatic patients as very important and

whenever evidence of infection was found in the paranasal sinuses radiation therapy was administered.

Among the first to report the value of irradiation in the treatment of the nasal accessory sinuses were Butler and Woolley[1,2] at the University of Oregon, who published their results in 1934. They reported on 450 of 700 patients with chronic sinusitis treated with roentgen therapy, and considered that 36 per cent were cured, 55 per cent improved, and 9 per cent slightly improved or not helped. From their studies they concluded that patients with hyperplastic membranes are the most likely to be helped, while those with polypi, atrophic rhinitis, chronic sinusitis, fibrosis, and those who had been unsuccessfully treated by radical surgery were the least benefited.

TABLE I

AVERAGE DURATION OF SYMPTOMS FOR VARIOUS AGE GROUPS IN 100 CASES OF ASTHMA

Age (years)	Duration (years)
0–10	2.0
11–20	5.0
21–30	11.0
31–40	11.8
41–50	17.6
51–60	11.3
61–70	7.5
71–80	7.7

The work of Butler and Woolley has later been confirmed by others interested in the roentgen therapy of the sinuses, particularly by Firor and Waters.[3] The latter, like Butler and Woolley, studied membrane sections from the sinuses before and after treatment in experimental animals and occasionally humans. They all agree that irradiation should not be used in acute sinusitis but can be used with beneficial results in the other types, especially subacute sinusitis and chronic sinusitis with thickened membranes.

In the group treated by Firor and Waters, cures were reported in 34 per cent, 38 per cent were considered markedly improved in which the symptoms disappeared completely in a short time, while 13 per cent were only slightly improved or not relieved at all. These figures coincide fairly closely with the results obtained by Butler and Woolley. Firor and Waters concluded that approximately 70 per cent of properly selected cases of sinusitis can be cured or markedly improved by irradiation. They regard the presence of a leukocytic infiltration in the sinus membranes an important factor for good results, thus explaining the negligible results in cases of fibrosis and atrophic changes where leukocytes were not found. Other workers, including Rathbone,[9] Hodges,[4] Osmond,[8] and others, have obtained similar results with roentgen treatment of the accessory sinuses.

The average age incidence of asthma is shown in the accompanying graph (Fig. 1) in which it will be observed that the most frequent occurrence of asthma in our series of patients lies in the age group forty to fifty, or 26 per cent. The age groups from twenty to thirty, thirty to forty, and fifty to sixty, show approximately an equivalent incidence. The lowest incidence of asthma occurred between the ages of seventy to eighty, and ten to twenty, while the incidence in children under ten years represents 10 per cent of all cases. The average duration of asthma in all patients included in this group is eleven years and seven months (Table 1).

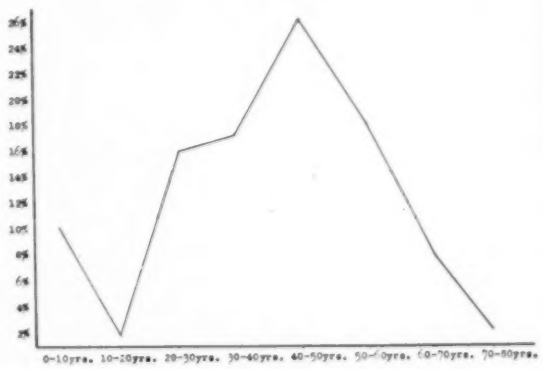

FIG. 1. The age incidence in a series of 100 consecutive cases of asthma.

The protocol reveals some interesting facts regarding infection, where we find that in 58 per cent of this series the white blood count ranges between 7,000 and 11,000 white blood cells per cubic millimeter. In 32 per cent the white blood count was above 11,000, but in only 10 per cent was it below 7,000. We have always regarded the white blood count as somewhat significant in evaluating the presence of infection in asthmatic individuals and generally more significant than the finding of organisms in the expectorated sputum, since large numbers of bacteria may be found in the bronchial secretions without necessarily causing trouble, while in other individuals even small numbers of organisms may produce very marked effects. A comparison of the white blood count before and after treatment is even more confirming when in practically every instance the blood count can be seen to drop as infection is eliminated. Figure 2 shows graphically the elevation of the white blood count before and after treatment in this series of cases. One can almost state that an elevation of the white blood count in asthmatic patients is significant of infection either in the bronchial tubes or in the sinuses, when, of course, the presence of infectious processes elsewhere in the body has been eliminated.

The presence of protein products from bacteria in the bronchial tubes may possibly produce two effects, one in which the protein simply irritates the bronchial tubes, and the other due to specific sensitization to these proteins, either or both of which may cause severe bronchial spasms. In other cases, the presence of bacteria probably stimulates bronchial secretions with accumulation of mucus, and it is well known that mucus alone may incite severe bronchial spasms. This view is certainly supported by observation of those individuals who clear up gradually but surely as the amount of mucus decreases during or after treatment.

The clinical response in most patients followed closely the decrease in the white blood count. Reference to Figure 2 shows that in all patients with chronic asthma and superimposed bronchial infection the range of the white blood count lies between 8,000 and 15,000 per cubic millimeter. The increase in polymorphonuclears is not significant and rarely occurs. Following radiation therapy, there is an almost immediate drop in the white blood count which tends to persist and eventually reaches an approximate normal level, usually quite early in the course of treatment.

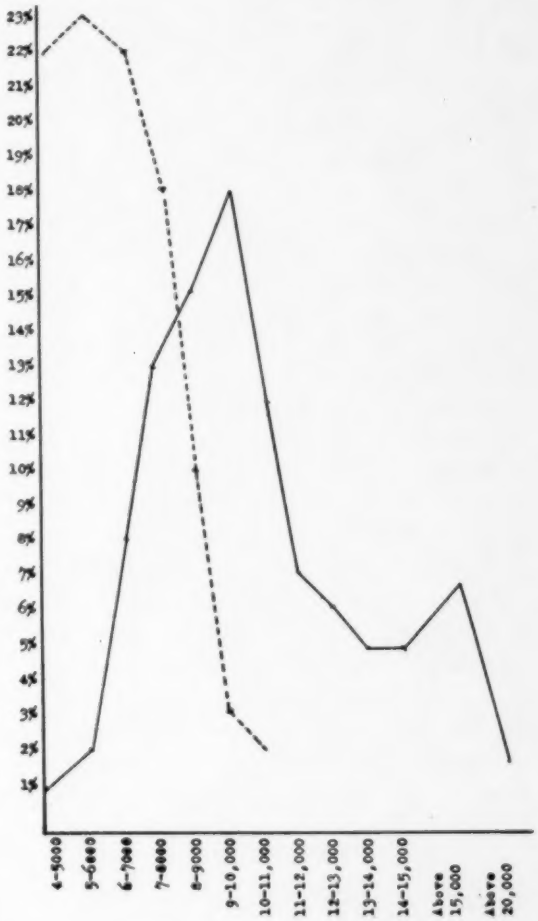

Fig. 2. The white blood count before and after radiation treatment. Before treatment——; after treatment----.

Table 11 reveals that in this series of patients, 24 per cent brought up no mucus at all, 11 per cent a slight amount of mucus, and 22 per cent only moderate amounts.

The remainder, or 43 per cent, expectorated large amounts, and in 51 per cent of all patients the secretions were found infected. Since various strains of organisms are normally found in the bronchial tubes, as well as the upper respiratory passages, it has not always been possible to say when a specimen from any individual is definitely infected. It is possible, with reasonable care, in practically every case to obtain cultures of either streptococci or staphylococci from the material even in normal individuals. We have regarded those patients infected who bring up mucus that is green, yellow, or yellowish-green, and where the white blood count is elevated. The common strains of streptococcus organisms are not pigment producing bacteria (except *Streptococcus pyogenes*) and the mucus is clear or gray. The temperature in these patients is usually normal, although an elevation of one or two degrees may occur in acute cases.

TABLE II

INCIDENCE OF MUCUS AND INFECTION

None	24%	
Slight	11%	
Moderate	22%	
Heavy	43%	
Infected		51%

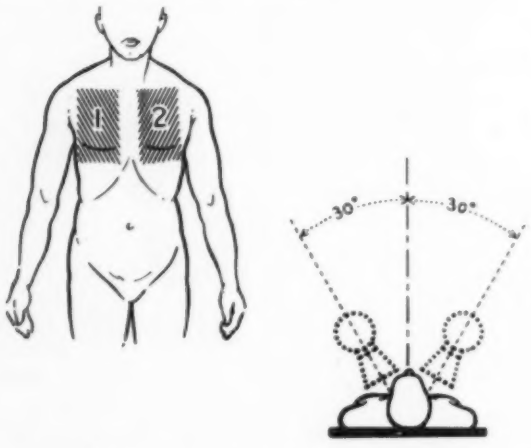

FIG. 3. Showing portals 1 and 2, angulation of tube for the "cross fire" technique to the anterior chest.

Our treatment of asthmatic patients by radiation therapy has varied somewhat in technique from that used by others. In this country Maytum and Leddy, and those employing this type of treatment, have advocated the so-called direct technique in which the purpose is that of concentrating the greatest amount of radiation in the hilar regions and the mediastinum. We have felt that irradiation should be more effective when distributed over a larger area of the lung where the bronchial tubes are most numerous and therefore have employed a so-called "cross fire" technique in which six distinct field areas of the chest are irradiated. The first fields are exposed with the patient lying on his back with the tube set at about a 45 or 60 degree angle, first on the right side and then on the left side. The average individual receives about 100 roentgens of filtered radiation to each field, and since two fields are irradiated at the same sitting the total dose is about 200 r daily. The next treatment is given to the corresponding fields of the posterior chest with the tube directed at an oblique angle from the posterior lateral aspect. The lateral fields are given by direct irradiation to the sides of the chest. Two exposures are generally given to each field in the course of the treatment, depending on the severity of the case and the amount of involvement in the bronchial tubes. Thus in the average individual a total dosage of between 800 and 1,600 r is administered through six portals. In severe cases where infection is great, or where the amount of purulent mucus is considerable, the total dosage may be increased above that for the average individual. Likewise, for milder cases and in children, the dosage is considerably below the average.

Figures 3, 4 and 5 show graphically the so-called "cross fire" technique which we have employed in the treatment of our patients. The majority of cases in the first series received irradiation by the direct method, as advocated by Maytum and Leddy, with most of the dosage directed in the region of the mediastinum. We have

been led to believe that irradiation of larger areas of the chest has given better results.

Most of our patients expectorated variable amounts of mucus. It was interesting to observe that generally within a period of three days to three weeks most individuals coughed up large amounts of thick, stringy, purulent mucus, oftentimes pitted with plugs, and usually in greater amounts than had previously occurred. In practically all cases where the individual was able to rid himself of large amounts of mucus, improvement was almost instantaneous and proportionate to the amount brought up. Generally within two or three weeks the expectoration of mucus had entirely ceased, and along with this change the patient became free of asthma. Sometimes the mucus changed a great deal in consistency, becoming more liquid or less tenacious and easier to bring up. At other times it changed in color but it always increased in amount temporarily, then gradually decreased until the individual became free of both mucus and asthma.

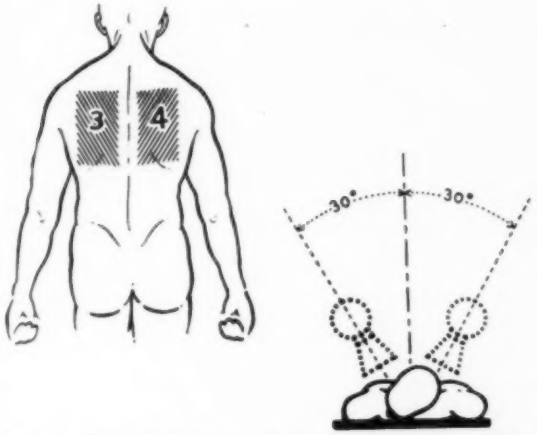

Fig. 4. Portals 3 and 4, showing positions of tube for "cross fire" technique to the posterior chest.

We have been able to follow this series of patients over a period of eighteen months, and during the first year from one to three courses of radiation therapy have been given. Fifty per cent of the cases were in the first group and received only one course of treatments during the first twelve months; 35 per cent were in the second group and received two courses; 15 per cent were in the third group in which three courses were given (Table III).

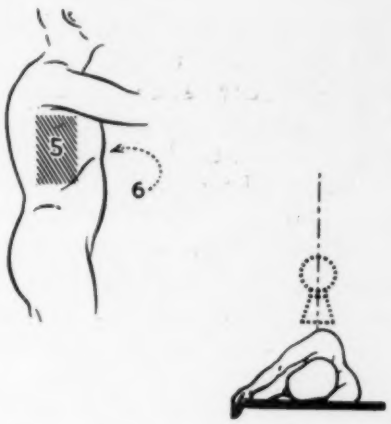

Fig. 5. Direct irradiation to lateral aspects of chest through portals 5 and 6.

Table III

NUMBER OF ROENTGEN COURSES FIRST YEAR

One course	50%
Two courses	35%
Three courses	15%

One course of treatment consists of fractional daily doses, totaling from 600 to 1,600 roentgens.

As to results, we have classified them as excellent, good, fair, poor, and none at all (Table IV). The table shows that they were divided as follows: Excellent, 39 per cent; good, 40 per cent; fair, 13 per cent; poor, 6 per cent; no results, 2 per cent. It has not been a simple matter to classify these individuals from a standpoint of results obtained, and this grading has been made entirely on the basis of each individual's

Table IV

APPROXIMATE RESULTS OF ROENTGEN THERAPY IN SERIES OF 100 CONSECUTIVE CASES OF ASTHMA

Excellent	39%
Good	40%
Fair	13%
Poor	6%
None	2%

progress during the course of eighteen months. We regard those with excellent results to represent patients who have been almost completely relieved, without recurrence of attacks during the eighteen months' period. Those with good results are individuals who have been almost completely relieved, although they may have had occasional light attacks that required the use of some simple aid such as the nebulizer, or tablets, or some other one of the various commonly used drugs. Some of these individuals received their second course of treatments during the year. Patients in the group regarded as obtaining fair results for the most part required three courses of radiation therapy during the twelve months period, and in addition to that had some trouble most of the time with occasional hard attacks of asthma that required the use of adrenalin hypodermically for relief. Those regarded as poor were not benefited by the treatment as far as we could tell. It is, of course, not fair to say that the good results were obtained because patients received radiation therapy, as they also received regular treatment consisting of desensitization where indicated, removal of offending foods, careful attention to the environmental factors, etc.

So far there have been no complications of the treatment other than nausea, which occurs in practically all patients, but it is not severe and quickly subsides within two or three days following the treatment. A few cases have complained of headache following irradiation of the sinuses. There have been a few patients sufficiently nauseated to vomit. Routinely all cases receiving radiation therapy are given 5,000 units of vitamin B_1 daily hypodermically. In those few individuals where nausea became marked, it was almost invariably controlled quite satisfactorily by injections of liver extract.

There are two possible dangers that must be considered in irradiation of these individuals. First, excessive irradiation may produce a pulmonary fibrosis; second, too much irradiation may produce roentgen burns of the skin. In order to avoid any possibility of occurrence of either process, we have kept accurate records on all patients as to the date of each treatment, the area treated, filters used, and total dosage, in addition to the distance and the voltage. We are confident that the amount of radiation given to these patients is within a safe range of dosage. We are sure that we are not producing a pulmonary fibrosis, and we are reasonably certain that the dosage can be repeated a number of times at intervals of three to four months or longer without danger of roentgen burns of the skin or damage within the chest. The amount of radiation which we are giving to the average patient could be repeated each year over a period of eight to ten years. The greatest danger appears to be in the possibility of these patients being treated in different parts of the country by irradiation without knowledge of previous exposure, as the treatment becomes accepted by others doing this type of work.

CONCLUSIONS

Although this group represents a series of 100 consecutive patients, the first we have treated by radiation therapy, we know our technique has greatly improved and that the next 1,529 patients following this group which have been treated have shown better results. Not only has the technique been more thoroughly standardized, but we have been able to select more accurately those individuals who could be expected to obtain most benefit. We are able at this time to offer the following conclusions on this method of treatment of severe asthma complicated by infection:

1. We are able to control asthma in many individuals who did not respond satisfactorily to methods previously used.

2. Radiation therapy in asthma is of definite value in those patients who show infection either in the bronchial tubes, the paranasal accessory sinuses, or both.

3. Infection has proved to be of greater importance in the asthmatic problem than previously regarded because of the remark-

able response of these individuals to radiation therapy.

4. Radiation therapy in asthmatic sufferers free of infection seems to have little or no effect.

5. The choice of technique is in favor of the "cross fire" method in which the dosage is concentrated over the greatest areas of the lungs where most of the bronchial tubes are distributed.

6. The method is not without danger but can be regarded as safe when accurate, detailed records are kept on each individual, and where the amount of radiation is maintained within a safe range of dosage.

7. We believe that irradiation of larger areas of the chest has given better results.

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RADIUM THERAPY AS AN AID IN THE CONTROL OF CHRONIC OTORRHEA

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CROWE and Baylor[1] in 1939 mentioned the fact that some cases of otitis media improved following radon treatments of the eustachian orifice for deafness. They did not, however, elaborate further on the subject. In 1941 Crowe and Burnam[2] further state that their radon method of treating the eustachian adenoid tissue has no effect on chronic otitis media. With these two statements in mind, we wish to present some evidence that, in certain selected cases of chronic otorrhea, treatment of the eustachian orifice with radium may be of value in controlling the otorrhea. We believe that as long as chronic otorrhea continues to form a large part of any otological practice, any specific therapy which may aid in the control of the otorrhea is of the utmost importance. We do not offer the method as a specific for all cases of chronic otorrhea.

We first noted improvement in cases of chronic otorrhea in the course of treating with radium the eustachian orifice of children with eustachian adenoids and hearing curves showing a predominant high tone loss. This observation led us to sort out from our files a large group of cases of chronic otitis media and revaluate them in respect to the possible etiology of their otorrhea.

The cases chosen for treatment with radium were those in which the persistent otorrhea appeared, on physical examination, to be due to hypertrophied lymphoid tissue in and about the eustachian orifice. All lesions of the upper respiratory tract, such as deviated nasal septum, sinus disease, tonsils and adenoids, which might contribute to the persistent otorrhea were excluded. Patients showing additional middle ear disease, such as polyps, granulations, caries of the ossicles, and patients with physical signs of mastoiditis of an active nature, were not included in the group to be treated. Roentgen examination was not made, as cases of chronic otitis media usually show a sclerotic mastoid and we felt, therefore, that the films would be of minimal value to us. The nasopharynx and the eustachian orifices were inspected directly with the nasopharyngoscope, using a 2 per cent pontocaine anesthesia in the nose to facilitate passage of the instrument.

The minimum amount of radium necessary to carry out the treatments is 25 milligrams (two 12.5 mg. needles). Each needle *per se* is composed of an alloy having a density of 8.7 and walls 0.3 mm. thick. Such a needle transmits 99.2 per cent of the gamma rays Of the total amount of radiation emanating from these needles, a relatively high percentage is beta radiation.

The applicator for carrying out the radium treatments is the same as that used in the treatment of deafness with radium.[3] The entire applicator consists of three parts —head, cap, and handle. The head is composed of two parallel chambers open at one end, and with brass walls 1 mm. thick. It is 3 cm. long, 0.6 cm. wide and approximately 3.5 mm. thick. There is an oval window 1.5 cm. long on one side of the head so that when it is placed in its treatment position against the os of the eustachian tube the radium is unfiltered other than the filter supplied by the walls of the needles. When loaded for treatment each chamber of the head contains one 12.5 mg. radium needle. The cap holds the two needles in place. It is an oval, flat piece of brass, 1 mm. thick

and of sufficient size to cover the open ends of the chambers in the head. There is a small hole in one end of the cap just large enough to allow the passage of the threaded end of the semiflexible steel wire handle. On the other end of the cap and on the underneath side is a small steel plug which fits in to the open end of one chamber of the head. The open end of the other chamber is threaded. When the threaded end of the handle is screwed into this, it not only retains the needle in place in the chamber, but also holds the cap on, which in turn secures the other needle firmly in its chamber. The semiflexible wire handle is 13.4 cm. long.

In order to save time in carrying out the treatments, we have constructed two such instruments, one the mirror image of the other. Previous experience in treating hemangiomata on the mucous membrane in children with these needles in contact and without additional filtration has established the erythema dose to be between 12 and 15 mg-hr. In view of the relatively high degree of sensitivity of lymphoid tissue to irradiation, we felt that approximately one-third of an erythema dose (5 mg-hr.) should be sufficient. Such a dose requires a treatment time of twelve minutes to one eustachian tube orifice, or twenty-four minutes if both orifices are treated with one applicator containing 25 mg. of radium. If four such needles (50 mg. of radium) are

Table I

CASE NO	NAME	SEX	AGE	EAR	DURATION OF OTORRHEA	CULTURE	DATE OF RADIUM TREATMENT	DURATION OTORRHEA AFTER RADIUM	DRUMS AFTER RADIUM TREATMENT	HEARING AFTER RADIUM TREATMENT	RECURRENCE OTORRHEA AFTER RADIUM TREATMENT
1	C.R.	F	25	BILATER'L	20 YRS. +	STAPH. A.	6-11-41	4 WKS	RT. HEALED LT. PARTIALLY HEALED	++++	NONE IN 3 MOS.
2	J.S.	M	20	RIGHT	INTERMITTENT	DRY	7-9-41	NONE	UNCHANGED	NO DATA	NONE IN 2 MOS.
3	J.S.	F	10	LEFT	INTERMITTENT	DRY	12-3-40	NONE	UNCHANGED	++++	NONE IN 9 MOS.
4	J.M.	F	16	BILATER'L	16 YRS.	STAPH. A.H.	1-22-41	2 WKS.	UNCHANGED	+	1 MO. LATER FOR 3 DAYS NONE IN 8 MOS.
5	J.P.	M	17	LEFT	15 YRS.	STAPH. A.H.	6-4-41	4 WKS	UNCHANGED	++++	NONE IN 3 MOS.
6	D.N.	M	15	LEFT	3 YRS.	NEG.	8-6-41	NO CHANGE	PERFORATION SMALLER	+	NO CHANGE
7	E.K.	F	8	RIGHT	8 YRS.	STAPH. A.H.	5-28-41	2 MOS.	HEALED	+++	NONE IN 2 MOS.
8	B.C.	F	14	RIGHT	14 YRS.	STAPH. A.H.	1ST 10-2-40 2ND 11-20-40	1 WEEK 1 WEEK	UNCHANGED	+ NO CHANGE	NONE IN 10 MOS.
9	A.C.	M	25	BILATER'L	25 YRS.	STAPH. A.	12-10-40	NONE	UNCHANGED	+	NONE IN 9 MOS.
10	I.D.	F	15	BILATER'L	12 YRS.	STAPH. A.	11-13-40	NO DATA	HEALED BY SCARRING	+	NONE IN 10 MOS.
11	R.F.	M	14	LEFT	NO DATA	STAPH. A.	5-5-41	2 WKS	UNCHANGED	+	NONE IN 4 MOS.
12	F.T.	F	13	LEFT	9 YRS.	B. PROTEUS	12-11-40	DISCHARGE LESS	UNCHANGED	+	DISCHARGE LESS
13	G.H.	F	6	RIGHT	7 MOS.	STAPH. A.	1-8-41	1 MO.	UNCHANGED	+++	8 MOS. LATER FOR 4 WK.
14	I.L.	M	12	LEFT	5 YRS.	B. PYOCYANEUS	11-6-40	3-5 DAYS	UNCHANGED	+	NONE IN 10 MOS.
15	G.P.	F	15	RIGHT	4 YRS.	B. PROTEUS-STAPH A.	11-11-40	DISCHARGE LESS	UNCHANGED	NO CHANGE	DISCHARGE LESS
16	M.L.	F	15	LEFT	7 YRS.	B. PROTEUS	10-23-40	2 WKS	UNCHANGED	NO CHANGE	NONE IN 11 MOS.
17	A.C.	M	25	BILATER'L	23 YRS. +	STAPH. A.H.	12-10-40	1 WK.	UNCHANGED	+	NONE IN 9 MOS.
18	P.J.	M	17	RIGHT	17 YRS.	B. PROTEUS	12-11-40	NONE	UNCHANGED	++++	NONE IN 9 MOS.
19	E.J.	M	11	RIGHT	11 YRS.	STAPH. A.	2-19-41	NONE	UNCHANGED	++++	NONE IN 7 MOS.
20	G.N.	F	23	LEFT	7 MOS.	STAPH. A.	1-29-41	DISCHARGE LESS	UNCHANGED	NO DATA	PATIENT LOST
21	D.G.	M	16	BILATER'L	10 YRS.	STAPH. A.	9-3-40	3 MOS.	RT. HEALED LT. PARTIALLY HEALED	++++	NONE IN 12 MOS.
22	I.L.	F	15	LEFT	5 MOS.	STAPH. A.	10-16-40	10 DAYS	HEALED	++++	NONE IN 11 MOS.
23	B.C.	F	14	RIGHT	10 YRS.	STAPH. A.H.	1ST 10-4-40 2ND 11-20-40	1 WEEK 10 DAYS	UNCHANGED	+ NO CHANGE	1 MO. LATER FOR 10 DAYS NONE IN 10 MOS.
24	M.B.	M	12	RIGHT	10 YRS. +	STAPH. A.	6-18-41	5 DAYS	UNCHANGED	NO CHANGE	1 MO. LATER FOR 8 DAYS NONE IN 2 MOS.
25	M.B.	F	15	RIGHT	INTERMITTENT	DRY	5-14-41	NONE	UNCHANGED	+	NONE IN 4 MOS.
26	M.C.	F	7	LEFT	5 YRS.	STAPH. A B. ALKALIGENES	7-23-41	± 2 WKS.	UNCHANGED	++	NONE IN 2 MOS.
27	B.C.	F	14	RIGHT	INTERMITTENT	DRY	10-2-40	NONE	UNCHANGED	+	NONE IN 11 MOS.
28	J.C.	M	10	BILATER'L	INTERMITTENT	STAPH. A. DIPHTHEROIDS	2-26-41	3 WKS	UNCHANGED	NO DATA	NONE IN 7 MOS.
29	P.L.	M	8½	BILATER'L	8 YRS. +	B. PROTEUS	1ST 11-27-40 2ND 9-17-41	4 WEEKS 4 WEEKS	UNCHANGED	++ +	7 MOS. LATER FOR 4 WKS. NONE IN 1 MO.
30	S.P.	F	13	RIGHT	13 YRS.	STAPH. A.	10-2-40	NO DATA	NO DATA	NO DATA	PATIENT LOST

+— 25 per cent improvement in hearing.
++— 50 per cent improvement in hearing.
+++— 75 per cent improvement in hearing.
++++—100 per cent improvement in hearing.

available and two applicators are used, both orifices can be treated simultaneously in twelve minutes after local anesthesia has been established.

We have found the application of one treatment of 5 mg-hr. (one-third of an erythema dose) sufficient in most instances.

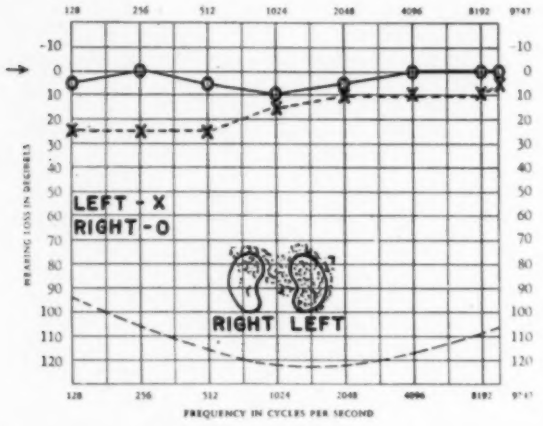

FIG. 1. Case 1. June 4, 1941. Prior to radium treatment. This patient showed a marked defect in the hearing of the left ear. The relative amount of adenoid tissue about the eustachian orifices is shown schematically.

Occasionally, a second treatment of like magnitude has been necessary in three months in order to bring about the desired results.

The actual treatment is carried out in the otology clinic. Following local anesthesia with 2 per cent pontocaine, the head of the applicator is passed through the inferior meatus with the oval window in the head toward the lateral wall. Owing to the shape of the applicator it will drop into position in contact with the eustachian tube orifice and remain fixed throughout the treatment.

Table 1 shows the results obtained in the treatment of chronic otorrhea in 30 carefully selected cases. In 4 cases healed drums resulted, and in 2 of these 4 cases the otorrhea had existed for ten and for twenty years, respectively. Five cases had recurrence of otorrhea. Two of these recurrences followed swimming and were of short duration, clearing without subsequent radium treatment. In 2 of the cases the recurrent otorrhea ceased following a second dose of radium. One case was without frank otorrhea, but the middle ear remained moist. In 3 cases we were unable to obtain a dry ear; 2 of these had less otorrhea, but in 1 case we failed entirely. All of these patients have received such other treatment of routine nature as was indicated. One additional case is mentioned which is not included in the charts. This case developed a surgical mastoid following an upper respiratory infection.

The following 4 cases are selected from a group of 35 cases treated. The 35 patients treated were carefully chosen in respect to the aforementioned criteria from over one hundred and fifty cases of chronic otitis media. The 4 cases illustrate the effectiveness of the treatment on the chronic otorrhea due to eustachian lymphoid hypertrophy and also show the effect on the hearing curve.

CASE 1 (Fig. 1 and 2). J. P., white male, aged seventeen, was first seen in the Otological Clinic of Strong Memorial Hospital on June 4, 1941. A history of intermittent otorrhea bilaterally following scarlet fever at two years of age was obtained. The otorrhea on the left had been constant for the last two years. Examination revealed a healed drum on the right, and a large

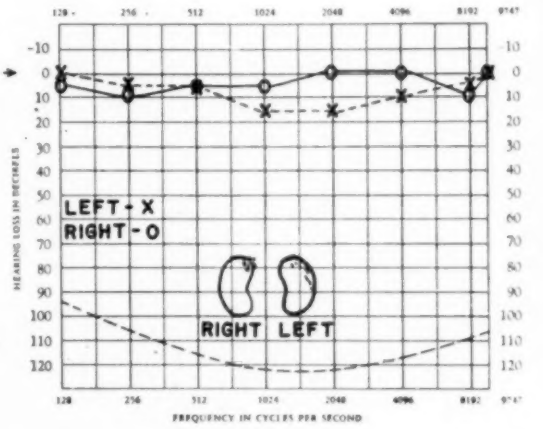

FIG. 2. Case 1. July 16, 1941. Six weeks following radium treatment. Audiogram shows marked improvement in hearing of the left ear, and the eustachian orifices are clear of hypertrophied lymphoid tissue. No otorrhea for one year and three months.

central perforation of the left drum, with otorrhea from which was cultured *B. proteus*. No granulations or polyps were seen in the left middle ear. There was adenoid tissue about the eustachian orifices, especially on the left. A 5 mg-hr. dose of radium was given June 4, 1941, by the intranasal route. Re-examination on July 16, 1941, showed both ears dry, the left drum showed no indication of healing. A good

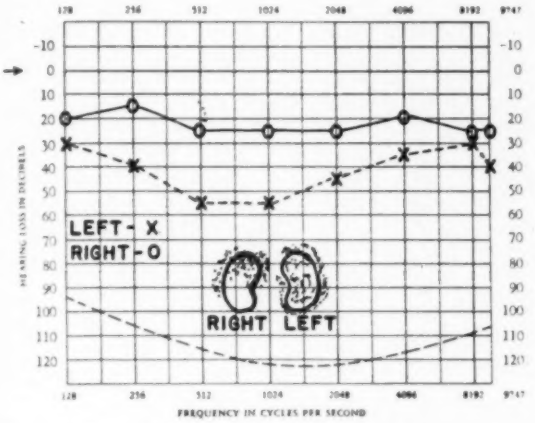

Fig. 3. Case II. The audiogram done May 27, 1941, shows the state of the patient's hearing previous to radium therapy. Again the eustachian orifices, represented schematically, show profuse studding with hypertrophic lymphoid tissue.

improvement in hearing was also noted, especially for the left ear, and the eustachian orifices appeared clean. There has thus far been no further otorrhea.

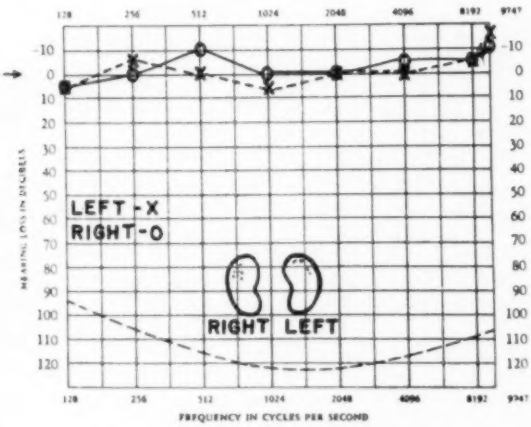

Fig. 4. Case II. Audiogram of August 6, 1941, shows a remarkable return in hearing and the eustachian orifices showed no hypertrophic lymphoid tissue. No otorrhea for three months.

Case II (Fig. 3 and 4). C. R., white male, aged twenty-five, was first seen in the Deaf Clinic of Strong Memorial Hospital on May 27,

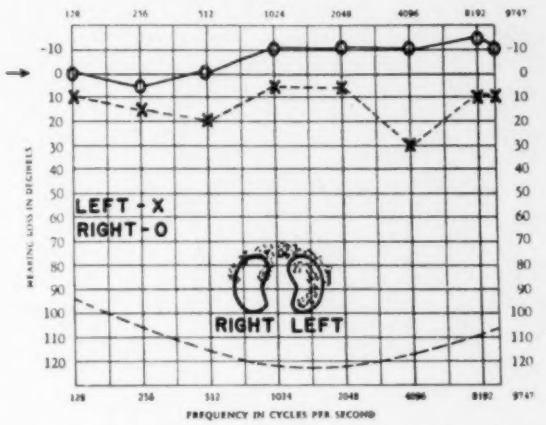

Fig. 5. Case III. Audiogram prior to radium treatment shows marked defect in hearing of the right ear, and there is profuse lymphoid hypertrophy about the eustachian tubes. Radium treatment given June 18, 1941.

1941. A history of ear disease since the age of nine months was obtained. His tonsils and adenoids had been removed in childhood. Otorrhea had been constant bilaterally for the

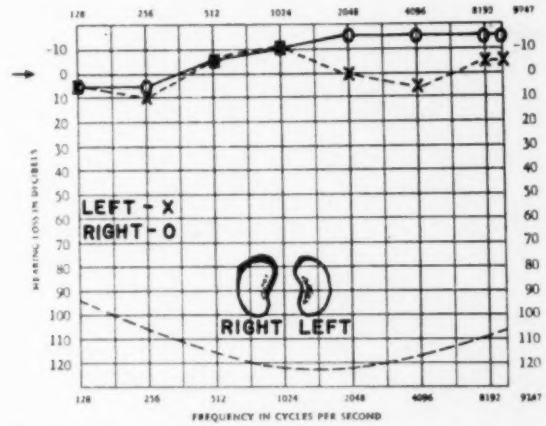

Fig. 6. Case III. One month later the audiogram showed some improvement in hearing of the right ear, and the eustachian tubes were clean. No further improvement in the hearing is expected in this case.

past five years. Examination showed a moderate sized perforation of the right drum and the left drum was completely destroyed. There appeared to be no caries of the ossicles, and no

granulations in the middle ears. Both eustachian orifices were heavily studded with lymphoid tissue, especially the left. Culture of both ears showed *Staphylococcus aureus*. A 5 mg-hr. dose of radium was given by the intranasal route. Examination on August 6, 1941, showed the right drum healed without scarring, the

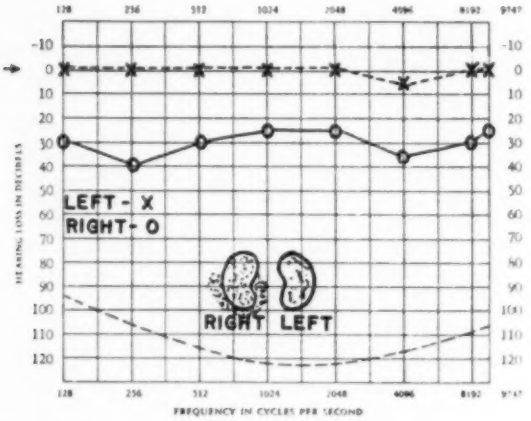

FIG. 7. Case IV. Audiogram prior to radium therapy shows rather marked defect in the left ear, and profuse bogginess of both eustachian orifices is charted schematically.

left drum partially closed and the middle ear was dry. The eustachian orifices were open. The patient had also had an excellent return of hearing.

CASE III (Fig. 5 and 6). M. B., white male, aged twelve, was first seen in the Otological Clinic of Strong Memorial Hospital because of constant otorrhea on the right for seven years; intermittently the discharge had been profuse and foul. Examination showed the left ear to be normal, but the right drum had been entirely destroyed with a fairly profuse discharge from which *B. proteus* was cultured. The tonsils and adenoids were chronically infected. Tonsillectomy and adenoidectomy were performed April 8, 1941, after which the discharge lessened but did not cease. Nasopharyngoscopy revealed swollen edematous eustachian orifices with hypertrophied lymphoid tissue about them. A 5 mg-hr. dose of radium bilaterally was accordingly given on June 18, 1941. The otorrhea on the right soon ceased and on re-examination July 16, 1941, the ear was completely dry. There had been no healing of the drum, and the eustachian tubes were open. The audiogram at that time showed very little improvement over the original hearing curves. The patient is now to receive a course of nicotinic acid in an effort to further improve the hearing in the right ear.

CASE IV (Fig. 7 and 8). P. L., white male, aged eight, was first examined at Strong Memorial Hospital on November 3, 1939, because of persistent otorrhea on the left since the age of four months. Examination showed the right ear to be normal. Both lower quadrants of the left drum had been destroyed and the discharge was foul and profuse. Tonsils and adenoids were removed cleanly at the age of five years. Culture of the aural discharge showed Friedländer's bacillus. The usual conservative measures of ear drops and dry wipings were prescribed. The otorrhea still persisted, but no granulations or polyps were noted in the left middle ear. Diffuse hypertrophy of the lymphoid tissue about the eustachian orifices was seen on November 11, 1940, and a 5 mg-hr. dose of radium was given by the usual intranasal route. By December 12, 1940, the ear was nearly dry and a slow improvement in hearing was noted. By April 2, 1941, the ear was dry, the eusta-

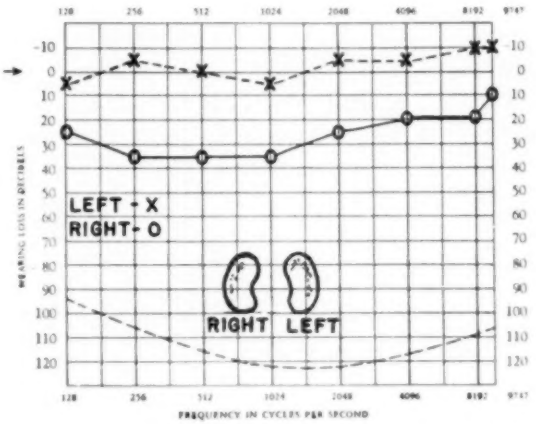

FIG. 8. Case IV. A year and a half later a nice improvement in hearing is seen, the ear dry, and the eustachian orifices clean.

chian orifices open, and there had been a good but not complete return of hearing. On the patient's last visit in December, 1941, the ear was still dry, the drum showed no evidence of healing, and the hearing showed no further improvement.

DISCUSSION

The 4 cases serve to illustrate what may be expected in selected cases of chronic

otorrhea treated with radium. The technique of the treatment is exactly the same as used in the treatment of deafness and was described by us in detail in our previous paper.[3] The dose is also the same, i.e., 5 mg-hr. of radium to each eustachian tube, repeated in six weeks to three months, if necessary.

It is important to remember that cases, to show good results, must be carefully selected. Patients who show concomitant chronic lesions such as ossicular caries, aural polyps or granulations, and involvement of the mastoid, will not show cessation of the otorrhea from irradiation of the eustachian tubes alone, but must have treatment, as indicated, for the middle ear lesions as well. It must be reiterated that pre-existent infectious processes or anatomical malformations of the upper respiratory tract may result in failure of the radium treatment of these cases. In suitable cases, the duration of the otorrhea seems not to be important.

The degree of healing noted in the tympanum will vary from none at all to complete sealing by what appears on inspection to be normal or scarred drum tissue or by thin atrophic membrane. If, as indicated above, there are polyps, caries of the ossicles, granulations, or severe involvement of the mastoid, the results of this treatment are not so satisfactory. Irradiation will, however, be of some aid in the treatment of these more complicated cases, especially if the eustachian orifice is found to be deeply buried in hypertrophied lymphoid tissue.

The irradiation of the eustachian orifice in these selected cases has been a definite aid in the control of the chronic otorrhea. In 4 instances the drums have healed and in these cases only can we say that the treatment cured the patient. The rest of the cases continue to have perforated drums and thus are open to reinfection from without as was the case with 2 patients who went swimming. Again the ears may start to discharge after a recurrent upper respiratory infection. To illustrate this, we cite a case which had cessation of otorrhea following treatment and which, after a severe nasopharyngitis, had a recurrence of the otorrhea and developed a surgical mastoid. From the above it is seen that the method described is by no means a cure for chronic otitis media, but in those cases where cessation of otorrhea is obtained, the patients are relieved of a most annoying symptom and the hearing may be improved as well.

CONCLUSIONS

1. A simple and effective means of treatment of selected cases of chronic otorrhea with a single small dose of radium has been described.

2. The cases suitable for treatment with radium are those in which persistent otorrhea is accompanied by hypertrophied lymphoid tissue about the os of the eustachian tube, and in which concomitant middle ear and active mastoid disease do not exist.

3. Healing of the tympanic membrane may occur, varying in degree from none at all to complete repair.

4. Pre-existent upper respiratory disease should receive the necessary attention, if the best results from irradiation of the eustachian tube are to be expected.

5. The hearing may be improved.

6. In those cases with persistent tympanic perforations, recurrence of the otorrhea may result either from without or from extension of an infectious process in the nasopharynx.

We wish to express our thanks to Dr. Clyde A. Heatly for making this work possible.

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RADON TREATMENT

MILD RADIUM THERAPY; DEFINITION AND METHOD OF APPLICATION

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I. GENERAL CONSIDERATIONS

THE discovery of radium led at first to the hope that radium salts could in one way or another be used, not only locally, but also for their effect on the body as a whole. Therefore the attempt was made to determine the dose of radium, either internally or by injection, which could be safely used. Here, however, obstacles arose which were difficult to overcome because of the complexity of treatment by radioactive bodies. Even now these difficulties have not been completely surmounted owing to a lack of proved biological facts, a perfectly clear understanding and a precise definition of the desired end to be attained.

II. TOXICITY OF RADIUM AND MESOTHORIUM

Difficulty arose from several reports showing that radium salts, several years after their ingestion, manifested an extreme and entirely unexpected toxicity. Numerous cases were published. For example, Flinn,[5] in 1932, reported the death of an individual who for two years and a half had been taking a water ("Radithor") containing 2 micrograms of radium salts per dose and whose body contained 40 micrograms of radium. Symptoms of severe poisoning (bone sarcoma) were observed in women workers in a watch factory who painted the watch dials with phosphorescent zinc sulphide containing radium and who were accustomed to point their brushes with their lips. In 1936 Dechaume[2] published several cases of necrosis of the jaw following injection of mesothorium.

These irreversible lesions caused by radioactive bodies resemble, to a certain extent, those observed in "strong" radium therapy (exceeding 5 mg.) used in the treatment of cancer, and are the result of two different properties of radium. The first of these properties consists of regular radioactive power, with the emission of gamma, beta, and especially alpha rays. The second, which is unexpected, is the affinity of long-lived radioactive bodies (radium, mesothorium) for certain tissues, especially the bone marrow and the bone cortex, an affinity similar to that of other metals of the calcium order for the skeleton. Because of this, deposits of radium or other radioactive substances are formed in the body and act as permanent sources of alpha, beta and gamma radiations, which after a quasi-inactivity of five, ten or even fifteen years are capable of bringing about the most serious conditions: bone necrosis, destruction of the bone marrow with consequent anemia, osteosarcoma, etc.

Thus, although Flinn[5] at first believed that a deposit corresponding to 10 micrograms of radium was the limit tolerated, his later observations and the observations of others point to the lowering of this limit to 1 microgram or even to a fraction of a microgram (Hirschi and Bodmer,[9] Rajewsky[13]).

Therefore, long-lived radioactive substances such as radium and mesothorium should be completely eliminated from "mild" radium therapy. They should be used only in short, local applications, suitably filtered, with the object of destroying a definitely limited mass of pathological tissue. The same is true of "radioactive salts," "radiferous earths" and "salts of rare earths," descriptions which should never be used in therapy because of their vagueness in designating complex products containing salts of radium or mesothorium. Their toxicity is unpredictable and they should not be used therapeutically as long as their composition is not definitely known and clearly defined.

III. HARMLESSNESS OF SHORT-LIVED RADIOACTIVE SUBSTANCES

On the other hand, no accidents have been reported after the use of short-lived radioactive substances of the type represented by radium emanation of radon. Up to now, in fact, doses as high as 100,000 millimicrocuries* a day (Happel[7]) ingested by mouth apparently have caused no ill effect; at least none have been reported. In addition, Hirschi,[5] Fernau and Smereker[4] have plainly demonstrated the absurdity of the idea that in such doses radon could be toxic. Innumerable experiences at radioactive and thermal spas, such as Luchon, Gastein, and others, are significant. It is obvious that if the daily ingestion of radon by the inhabitants of such spas, year after year and generation after generation was harmful, the geographical pathology would long ago have shown this fact.

At Joachimsthal, Czechoslovakia, where the miners work all through the year in an atmosphere of considerable radioactivity (2×10^{-12} to 6×10^{-12} and even 2×10^{-11} millimicrocuries per cubic centimeter), the malignant pulmonary tumors observed are now considered to be due to the dust of arsenic and chromium and particularly of radium contained in the air of the mines, not to radon itself. If radioactivity has any part in the production of these tumors, it is in the dust containing radium salts or other long-lived substances. Flinn[6] believes, however, that the presence of radon in the air may have had an effect on the absorption of some toxic metals but concludes that if there is a toxicity of radon at all, it may appear in other organs rather than in the lung.

IV. DEFINITION

These considerations lead us to give what has hitherto been lacking—a precise definition of "mild" radium therapy, internal radium therapy or radon therapy. It is a method of treatment in which radioactive substances are used internally by ingestion, or externally by local application, such as is done at radioactive spas (by drinking, by baths or by mud). However, in "mild" radium therapy doses larger than in the spas can be used in order to obtain better results without provoking any irreparable lesions in the body. This is in distinction to "strong" radium therapy which does cause such lesions and which is used almost exclusively in the local destruction of neoplastic tissue.

V. PREPARATION OF RADON

Radon is the only substance which can be considered suitable in mild radium therapy, although Weil,[17] Duvoir and Layani,[3] and some others, have for years used thorium which undoubtedly entails greater risks than radon. The preparation of radon for therapeutic use entails considerable obstacles on account of its short life and requires, therefore, complicated procedures. All radioactive preparations with radon as base and free of radium have hitherto had to be prepared as they were needed. An emanation producing apparatus was necessary into which the vehicle (water, oil, charcoal, etc.) had to be introduced for an exactly determined time in order to be charged with radon to the desired extent. After this time, the preparation should be used without delay as delay would decrease its radioactivity.

VI. AUTHOR'S METHOD

The method which was devised for biological investigations in the presence of a constant concentration of radon obviates this grave disadvantage. It is based on the principle that, in a closed space, it is possible to bring about a radioactive equilibrium between a determined quantity of radon and an insoluble salt of radium measured in such a way as to replace exactly, and so to speak, atom for atom, the radon which disappears in the course of its natural disintegration. It is obvious that this method must be adapted to the nature, to the chemical properties, and above all, to

* 1 millimicrocurie equals 10^{-9} curie

the physical properties of the medicament with which one desires to combine the radon. In addition, it will be necessary to make adjustments for the various vehicles whose choice is determined by the disease and the method of administration. There are, therefore, described the adaptations for the following methods of administration.

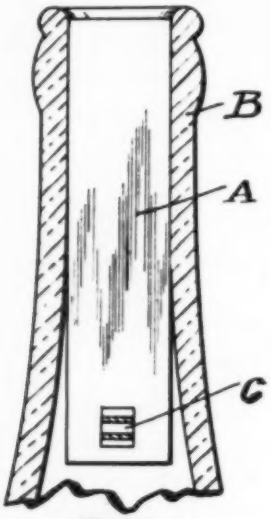

Fig. 1

a. *Oral Administration.* A constant degree of radon can be maintained in mineral waters, both naturally and artificially radioactive. The method consists of introducing into the bottle when it is being filled either at the radioactive spring or, if it is artificial, in the factory, a strip of mica (Fig. 1) (*A*) which is held to the neck of the bottle (*B*) by its elasticity. This strip serves as support for a glass tube (*C*) containing in the form of an insoluble salt, the quantity of radium which is exactly in equilibrium with the radon contained in the water. For the sake of safety, the radium salt is separated from the liquid by a semipermeable membrane.

Dosages of radioactivity extending over several years have demonstrated an absolute constancy in the radon content, without revealing the slightest trace of radium in the water.

The same method may be applied to any other medicines preserved in bottles.

b. *Subcutaneous, Intramuscular or Intravenous Injection (Vesical Instillation).* Figure 2 shows an ampule containing a radioactive liquid for injection. The insoluble radium salt is enclosed in the semipermeable membrane (*D*) and inserted between two plates (*E*) of unoxidizable metal, fastened on a support (*F*) which is elastic, keeping the apparatus in a fixed position inside the ampule (*G*). In this form the device can be sterilized, even in the autoclave.

For subcutaneous and intramuscular injections, as well as for vesical instillations, an oily vehicle is recommended. This permits the complete utilization of the radon employed because of its high degree of solubility in oil, which is more than 100 times that of its solubility in water.

c. *Rectal and Vaginal Administration (Suppositories).* In order to maintain a constant content of radon in suppositories, the insoluble radium salt which is to maintain equilibrium with the quantity of radon contained in the suppositories is placed in such a way that it is easy to withdraw it at the time of use (Fig. 3). This radium salt is placed in the cavity (*H*) of the metal support (*I*) and covered evenly with a very fine membrane applied directly on the metal

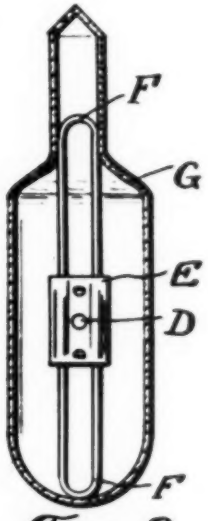

Fig. 2

support, the latter being buried in the radioactive suppository (*J*). In order to prevent loss of emanation through diffusion in the air, the suppository is placed in a glass tube (*K*) hermetically sealed by the stopper (*L*).

Before using, the suppository is removed from the receptacle in which it is enclosed and the support (*I*) is withdrawn.

It should be noted that this method permits the choice of any vehicle whatever for the radon. It may be a gas, a liquid solution (aqueous or oily), or a solid (fatty substance, gelatin, etc.), the choice being made by consideration of the rapidity of diffusion or elimination, which is, in the last analysis, the solubility of radon in each medium.

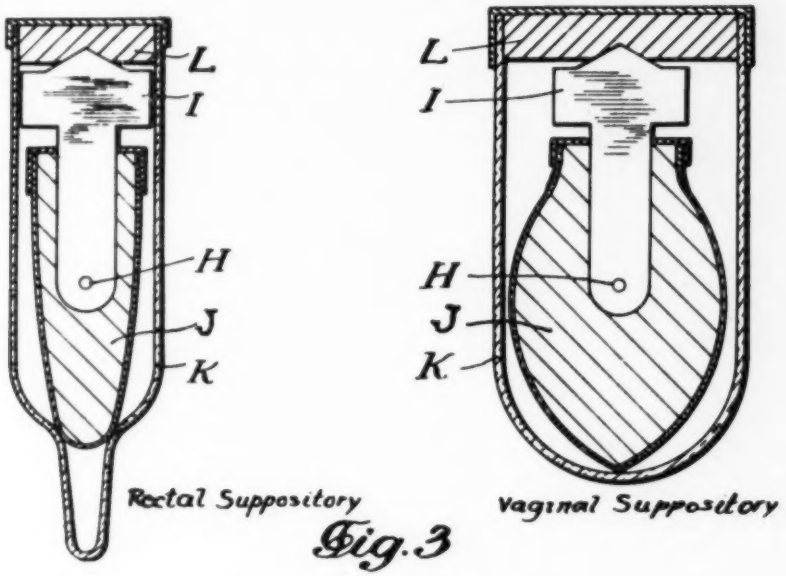

Fig. 3

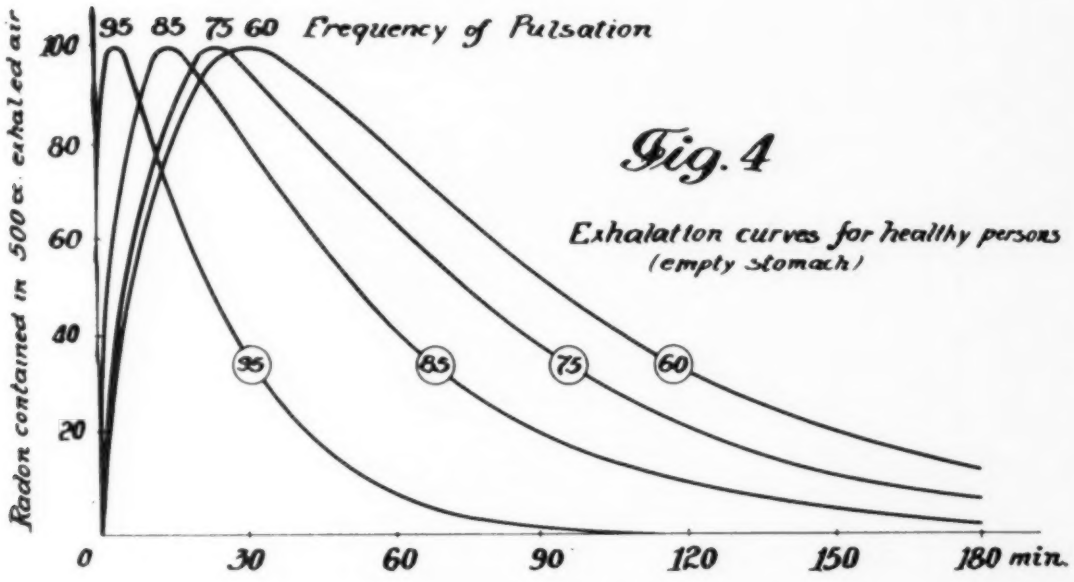

Fig. 4

Exhalation curves for healthy persons (empty stomach)

VII. THE ELIMINATION OF RADON

The largest part of radon ingested is eliminated by the lungs. In normal persons speed of elimination generally depends on

the pulse rate. A person with a very rapid pulse will eliminate radon much more rapidly than one with bradycardia. Figure 4, which was taken from a publication by Meyer,[12] shows the experimental results of largely on the disease. The following illustrations show some curves by Meyer for patients with pulmonary disease (Fig. 5), and pneumothorax (Fig. 6). Also, if the radon has been taken orally, elimination

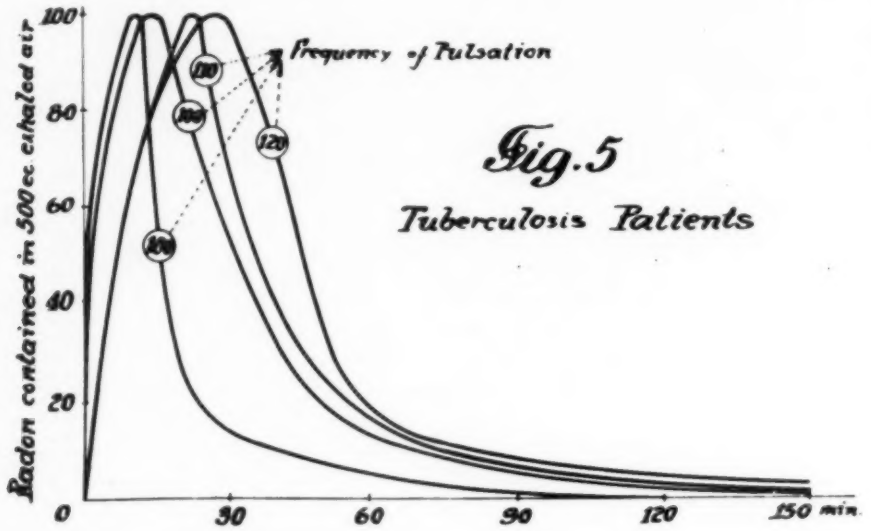

Fig. 5

Tuberculosis Patients

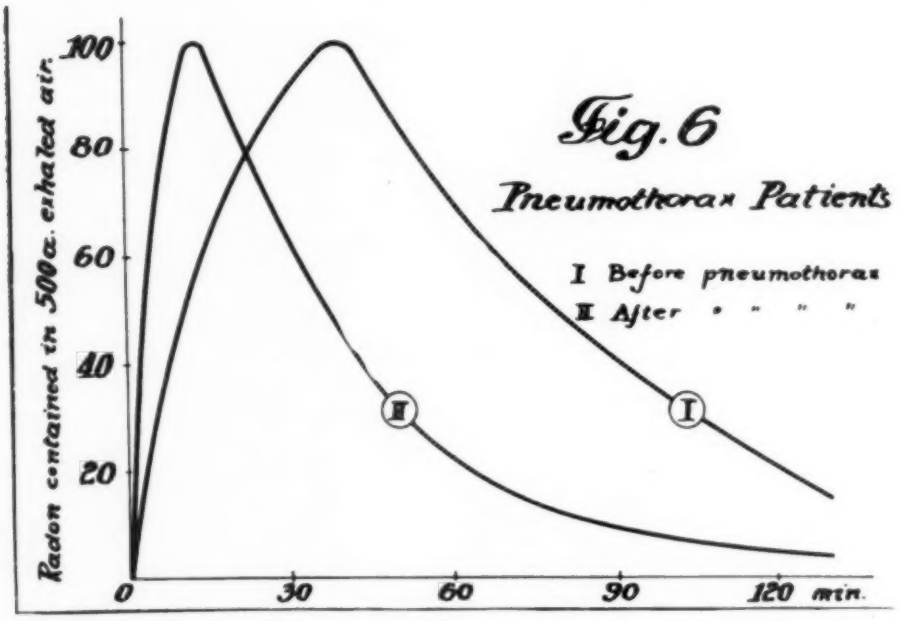

Fig. 6

Pneumothorax Patients

this exhalation. In general, it may be stated that radon is completely eliminated at the end of two or three hours (Fig. 4).

A sick person eliminates radon in a different way from a perfectly healthy one. Thus the curve of elimination depends will vary according to whether or not ingestion was made on an empty stomach (Fig. 7). The radon water may also have been taken in small sips. Figure 8 clearly illustrates this point.

If the quantity of water and radon in-

gested at one time gives the curve just seen, the same dose taken at ten different times, a tenth every five, ten or twenty minutes, gives wavy curves with lower summits. doses as by absorbing it all at once, for example, after a meal when the stomach is full. This phenomenon is explained by the presence in the stomach of a certain quantity

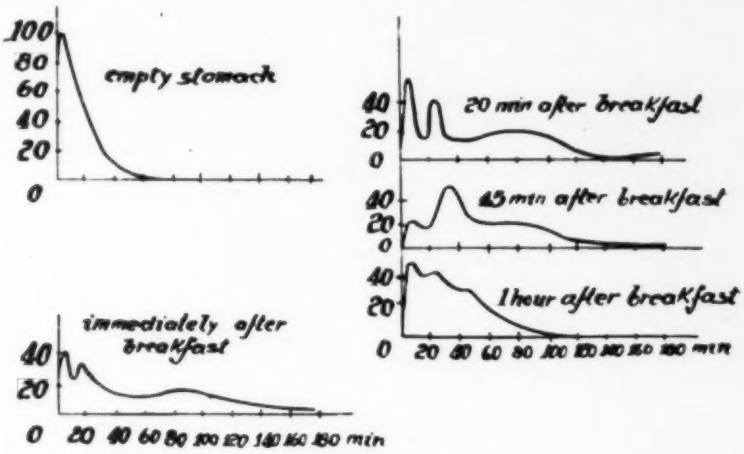
empty stomach
20 min after breakfast
45 min after breakfast
1 hour after breakfast
immediately after breakfast
0 20 40 60 80 100 120 140 160 180 min

Fig. 7

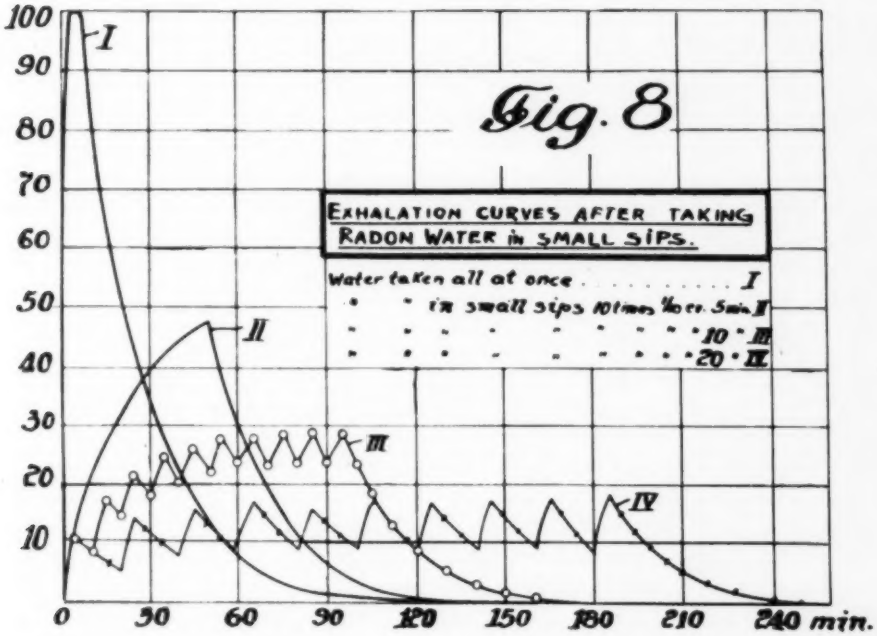
Fig. 8
EXHALATION CURVES AFTER TAKING RADON WATER IN SMALL SIPS.
Water taken all at once I
" " in small sips 10 times ½ cc. 5 min. II
" " " " " " " " 10 " III
" " " " " " " " 20 " IV
I
II
III
IV
0 30 60 90 120 150 180 210 240 min.

Thus the body can be kept almost constantly under the influence of radon and its action may be prolonged.

In comparing Figures 7 and 8, it is apparent that the action may be prolonged just as well by ingesting radon in small of fats. At room temperature these latter absorb about 100 times as much radon as water does. Consequently these fatty substances are slow to give up the radon they contain in solution. Also, radon taken after a meal is not diffused in the body as

quickly, for it is retained in the digestive tract as long as the fats themselves. It is fixed much more strongly by fats than by aqueous liquids which constitute the principal mass of the bodily tissues.

From a practical point of view, then, it is better to administer radon in the form of a fatty ointment. This has been done effectively for more than twenty years, especially in local treatments.

This method should be more generally used for it yields results greatly resembling (as shown by Meyer[12]) those attained by ingestion in small mouthfuls; that is, it maintains the body under the radon influence, if not continually, at least for a prolonged time, while the aqueous solution has only a momentary effect.

The solutions in fatty substances may be used not only for the skin, but also for all the natural cavities: rectum, vagina, bladder, urethra, nose, pharynx, bronchi, and perhaps even the pleura (oleothorax).

VIII. CONSTITUTION OF THE ACTIVE DEPOSIT

There remains now the question of the posology of radon; but for that one must examine the question of the constitution of the active deposit.

In emitting radiations, all radioactive substances, radon included, give birth to a succession of new radioactive elements belonging by their origin to one of the three radioactive groups. These constitute the "active deposit," in the case of radon, Ra A, Ra B, Ra C, Ra C′, Ra C″, Ra D, Ra E, and finally Ra F or polonium.

Ra A, Ra B and Ra C disappear so rapidly that they need not be considered. Actually the period of demi-transformation of Ra B, the longest living of these substances, is only 26.8 minutes. Only Ra D—whose demi-transformation is sixteen years—and its successors, need be taken into serious consideration. According to Hirschi's[8] calculation, oral ingestion of 4,000 millimicrocuries daily is followed by the elimination of 3,960 millimicrocuries. This leaves 40 millimicrocuries which disintegrate in the body and consequently help to create an active deposit of radium D. These 40 millimicrocuries a day, in the course of a year will accumulate in the body the following amounts of Ra D, Ra E and Ra F:

Ra D	8.6×10^{-11} grams
Ra E	3.8×10^{-14} grams
Ra F	4.6×10^{-13} grams

As a matter of fact, a large part of these substances is eliminated from the body before acting on the tissues, a phenomenon which has not been taken into consideration in these calculations but which is nevertheless important, as lead, for instance, whose chemical affinities are similar to Ra D, disappears from the tissues to a great extent and in a relatively short time.

Fernau and Smereker[4] also made calculations, adopting as a starting point the daily ingestion of 3,640 millimicrocuries. Their figures for the active deposit are:

Ra D	5.06×10^{-12} grams
Ra E	3.13×10^{-15} grams
Ra F	8.23×10^{-14} grams

The rate of accumulation in the body of Ra D, Ra E, Ra F(polonium), calculated by Hirschi, corresponds to that found by Fernau and Smereker, the apparent difference arising principally from the fact that Hirschi, as mentioned above, did not take into consideration the fact that these three substances are partially eliminated.

Let us now consider the effects that such a deposit may produce. From the chemical viewpoint, it may be noted that Ra D, Ra E and polonium are respectively isotopes of lead, bismuth and tellurium. The idea of chemical toxicity from these three simple substances in doses of 10^{-15} to 10^{-11} gram (0.000,000,000,001 to 0.000,000,01 milligram) is, without doubt, untenable. There remains the question of physical toxicity, which may result from the energy liberated in the form of beta rays of Ra D and Ra E and alpha rays of polonium. If we take as the basis of these calculations the results obtained by Hirschi, that is, purposely overlooking the elimination of Ra D, Ra E and Ra F, which may go as high as 90 per

cent of the quantity ingested, the calculation may be made as follows: 8.6×10^{-11} gm. of Ra D contains $8.6\times10^{-11}\times2.88\times10^{21}=2.48\times10^{11}$ atoms. The radioactive constant of Ra D being $1.00\times10^{-9}\times\text{sec}^{-1}$, the number of atoms which disintegrate per second will be: $2.48\times10^{11}\times1.00\times10^{-9}=2.48\times10^{2}$. Granted that, according to Rutherford,[15] the disintegration of Ra D emits 1.5 beta rays per atom disintegrated and the energy produced by each of these rays is on an average 6.21×10^{-8} ergs, the energy liberated per second will be as follows: $2.48\times10^{2}\times1.5\times6.21\times10^{-8}=23\times10^{-6}$ or 2.3×10^{-5} ergs.

Proceeding in a similar fashion for Ra E, whose radioactive constant is $1.66\times10^{-6}\times\text{sec}^{-1}$ and which emits, per atom disintegrated, 1.06 beta rays each having an energy of 4.491×10^{-7} erg, the energy liberated per second by 3.8×10^{-14} grams of Ra E is: $3.8\times10^{-14}\times2.88\times10^{21}\times1.66\times10^{-6}\times1.06\times4.491\times10^{-7}=8.65\times10^{-5}$ ergs.

In calculating the energy liberated by 4.6×10^{-13} grams of polonium it must be taken into consideration that its radioactive constant is $5.88\times10^{-8}\times\text{sec}^{-1}$ and that the alpha ray emitted in the course of the disintegration of each atom has the kinetic energy of 0.84×10^{-5} ergs. The energy liberated per second by this quantity of polonium is: $4.6\times10^{-13}\times2.88\times10^{21}\times5.88\times10^{-8}\times0.84\times10^{-5}=6.54\times10^{-4}$ ergs. To summarize:

8.6×10^{-11} grams of Ra D liberate	2.3×10^{-5} ergs per second
3.8×10^{-14} grams of Ra E liberate	8.7×10^{-5} ergs per second
4.6×10^{-13} grams of Ra F liberate	65.4×10^{-5} ergs per second
Total	76.4×10^{-5} ergs per second

One microgram of radium anchored in the body produces, with all its products of disintegration, 1.976 ergs per second. The above mentioned quantities of Ra D, Ra E and Ra F (polonium) thus produce an energy corresponding to that emitted by 39×10^{-5} micrograms of radium or to 0.000,000,39 milligram of radium fixed in the body.

It is known that the skeleton and certain other organs of the human body possess a certain very weak radioactivity, due to ingested food and drink. Fernau and Smereker calculate this radioactivity at 1.5×10^{-5}, or 0.000,015 milligram. The amount of long-lived radioactive substances corresponds, therefore, as far as its physical effects are concerned, to a maximum of 2.6 per cent of the natural radioactivity of the human body. We must admit that this radioactive deposit has been formed by the ingestion of an exaggerated quantity of radon. As was demonstrated above, the active deposit which served for comparison was calculated without taking into account the elimination of Ra D, Ra E and Ra F, and this elimination is relatively large. We may then conclude that the daily ingestion of approximately 4,000 millimicrocuries, in the course of a year will not, in the long run, have any harmful effects.

These theoretical deductions, as stated above, are confirmed by long empirical experience at radioactive spas. Disagreeable or toxic effects of radioactivity have never been observed among the natives or the employees of such spas who have been exposed without taking any precautions, to the inhalation of considerable quantities of radon for years.

IX. CONCENTRATION OF RADON TOLERATED BY THE BODY

Investigations in the sphere of industrial hygiene allow us to approach the question from another angle. Barker[1] calculated that workers in a factory for luminous watch dials were exposed to an atmosphere containing 5×10^{-11} curies per liter, that is, 500 times the quantity of radon found in ordinary air. Let us grant that the constant presence in the body of 3,600 milliliters of air corresponds to 4×10^{-8} milligrams of radium. The human body contains, according to what was stated above, 1.5×10^{-5} milligrams of radium. The radiation of radon will therefore be at the rate of 0.3 per cent of the radiation due to natural radioactivity of the body. Therefore, according to Barker, any toxic effects in these work-

ers, by ingestion of radon, are inconceivable.

In a similar study on the radon content of the air in radium laboratories, Read and Mottram[14] admit that the "tolerance concentration" for radon is approximately 10^{-11} curie per cubic centimeter, or 10^{-8} curie per liter.

The air in the Joachimsthal mines contains 2×10^{-12} to 6×10^{-12}, sometimes even 2×10^{-11} curie per cubic centimeter. Nevertheless, the pulmonary carcinoma observed in the workmen of these mines is attributed by these authors to the chromium and arsenic in the dust of the atmosphere. Moreover, as Humphris[10] remarks, radioactive dusts may be deposited in the lungs as a result of employing electric drills. Tschelnitz[16] believes that in addition to the dust of radioactive substances, quartz dust may also be a very important factor in the development of lung cancers. Flinn[6] asks whether, in such concentrations, radon may not produce some deleterious effect in men working all year and for many years in this atmosphere. At present it seems that this question can be answered only negatively.

X. DOSAGE USED IN TREATMENT

We are now in a position to approach the important question of dosage of radon. The calculations of Hirschi[8] and of Fernau and Smereker[4] have shown that the energy produced by the long-lived active deposit following the ingestion on an average of 1,460,000 millimicrocuries in the course of a year is at the rate of 2.6 per cent of that produced by the natural radioactivity of the body. Such a change in the normal radioactivity is certainly too slight to explain any toxic effect whatever. On the other hand, according to the previously mentioned authors Flinn,[5] Hirschi and Bodmer,[9] as well as Rajewsky,[13] 1 microgram and, in certain cases, even a fraction of a microgram anchored in the organism should be considered as the limit beyond which a deposit may become dangerous. It is preferable to fix this limit at 0.01 microgram in order to be on the safe side as far as calculations are concerned. The natural radioactivity of the body being 1.5×10^{-5} milligram, this deposit is about seven-tenths of that amount.

Speaking of radon, we can conclude that its ingestion should be considered as harmless as long as the radioactive deposit in the body formed thereby does not exceed an equivalent of 0.01 microgram of radium. In other words, an internal radon treatment should not be pursued above the limit dose which produces a radioactive deposit liberating in each second an energy more than 70 per cent of the natural radioactivity of the body.

An average of 1,460,000 millimicrocuries of radon ingested in the course of one year produces, as stated above, 2.6 per cent of the natural radioactivity of the body. Thus 70 per cent of the radioactivity would be produced by 27 times that amount—that is, by about 40,000,000 millimicrocuries or 40 millicuries of radon. This dose has been established without taking into account the elimination of Ra D, Ra E and Ra F (polonium); nevertheless, it would not be wise to exceed this maximum amount in treatment.

Accordingly, doses of 500 to 1,000 millimicrocuries per dose and of several thousand millimicrocuries per day may be considered far below the toxic dose. On the other hand, doses as high as 300,000 millimicrocuries per day, as recommended by some German authors, may probably be too high.

XI. CONCLUSION

A new method of "mild" radon application in therapy has been described and the limit of dosage for such internal radon treatment has been calculated. This maximum dosage has been found to be 40,000,000 millimicrocuries or 40 millicuries of radon in the course of one year.

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EFFECT OF ROENTGEN IRRADIATION ON CAPILLARY PERMEABILITY AND INFLAMMATION IN THE SKIN OF THE RABBIT*

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ONE of us has been interested in an experimental study of capillary permeability and inflammation in the skin of the rabbit.[10,11,12] In these studies, trypan blue is injected intravenously and the time and the quantity of the dye that localizes and concentrates in the areas of inflammation are observed. Histological preparations of the skin are made to study the type and the rate of development of the inflammatory reaction. It has already been shown by this technique that trypan blue localizes and concentrates in areas of inflammation in the skin of the rabbit only during a specific interval following either the application of xylol or the intradermal injection of other irritants. There is a progressive diminution in the intensity of the staining of the xylol treated areas of skin when xylol is applied at varying intervals preceding the intravenous injection of this dye. When xylol is applied to the skin three hours or longer before the dye is injected, essentially the same amount of dye localizes and concentrates in the areas of inflammation as in the untreated skin of the same rabbit. The greatest amount of dye localizes and concentrates in the areas of skin where xylol is applied immediately preceding the intravenous injection of the dye. It becomes obvious from these experimental studies therefore that the localization and the concentration of trypan blue is not dependent upon the presence of hyperemia and edema.

Polymorphonuclear leukocytes begin to appear in the extravascular tissues in the xylol treated areas of skin approximately two hours following the application of the irritant. The quantity of trypan blue that localizes and concentrates in an area of skin where xylol is applied two hours preceding the injection of the dye is much less than that which localizes and concentrates in an area of skin where xylol is applied immediately preceding the injection of the dye. It is obvious, therefore, that the time in which trypan blue localizes and concentrates in an area of inflammation produced by xylol is different from the time in which polymorphonuclear leukocytes begin to appear in the tissues. Furthermore, at the time the greatest number of leukocytes are present trypan blue fails to concentrate in the xylol treated areas of skin.

It has been suggested that following an intravenous injection of trypan blue the dye localizes and concentrates in an area of inflammation as a result of a change in the permeability of the cells.[12] The interval in which this permeability is increased over that of the normal cells is influenced by both the type of irritant and the degree of injury. The greatest degree of injury apparently occurs immediately following the application of xylol to the skin. The injured cells return to normal within a period of approximately three hours as indicated by the quantity of dye that localizes and concentrates in the area at this time.

This paper is a report of our observations on the localization and the concentration of trypan blue, following an intravenous injection, in local areas of the rabbit's skin treated with roentgen rays. It also includes a description of the pathological changes in these areas of skin. In subsequent publications one of us will report the results of similar experiments in which ultraviolet and infra-red rays are used rather than the roentgen rays.

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METHODS AND MATERIALS

Adult rabbits are used. The skin over the sides and the abdomen is carefully shaven twenty-four hours or longer before the experiment begins. Local areas of skin are treated with roentgen rays at varying intervals before 10 to 15 cc. of a 0.2 per cent saline solution of trypan blue is injected into the marginal vein of the ear. Observations are made on the areas of irradiated skin that become blue. The time of the appearance of the dye in these areas is also recorded.

The apparatus used for irradiating the skin is a Wantz Jr. transformer with a milliamperage controlled by a General Electric Kersley filament stabilizer. The rabbits are covered with a sheet of lead in which there is a window 15 mm. in diameter. The following factors are used in the treatment of the majority of the animals: 86 kv. (peak), 5 ma., 7½ min., 20 cm. target-skin distance, no filter. In the experiments the length of the exposure is either 2½ minutes, 5 minutes, 7½ minutes or 10 minutes. The machine delivers 272 r per minute. The doses are as follows: 680 r, 1,360 r, 2,040 r and 2,720 r.

The irradiated portions of skin in some of the rabbits are removed at varying intervals and fixed immediately in a 10 per cent solution of formalin. Sections are prepared and stained with hematoxylin and eosin.

EXPERIMENTAL

Localization and Concentration of Trypan Blue in Areas of the Skin Irradiated with Roentgen Rays.

In this experiment 24 rabbits were used. A few of these animals were irradiated for varying intervals with different quantities of radiation. The time at which the skin was irradiated before the dye was injected is shown in Table I. The irradiated areas of skin became blue within a period of five to thirty minutes following the intravenous injection of trypan blue. The intensity of the staining varies in the different areas of the same rabbits and also in the different animals. The dye localizes and concentrates more frequently in the areas of skin irradiated sixty minutes preceding the injection of the dye than in any of the other irradiated areas.

A second group of 14 rabbits were treated with roentgen rays (86 kv. peak, 5 ma., 7½ min. at 20 cm. target-skin distance) over local areas of the skin at varying intervals before the dye was injected. The technique used on these rabbits was the same as that in the experiment discussed above except that the last area of skin was treated immediately following the injection of the trypan blue. The results of the localization and the concentration of the dye in this group of rabbits is shown in Table II. The dye localizes and concentrates in 7 of the 14 areas irradiated immediately following the injection of the dye. The dye localizes and concentrates in each of the 14 irradiated areas when the trypan blue is injected one hour following the irradiation. This dye does not concentrate in either of the 20 areas irradiated from two to twenty-one hours before the dye is injected.

The composite data in this experiment (Table III) show that the dye localizes and concentrates only 6 times in 29 observations when the interval between the irradiation and the injection of the dye is thirty minutes; 35 times out of 46 observations when the interval is sixty minutes; 3 times out of 30 observations when the interval is two hours; 0 times out of 58 observations when the interval is from three to twenty-one hours.

The following protocol (rabbit No. 995) illustrates this localization and concentration of trypan blue in the skin of the rabbit following irradiation. The dose is 86 kv. (peak) with no filter, 2,040 r at the rate of 272 r per minute.

1:00 P.M. Skin irradiated in Area 1
2:00 P.M. Skin irradiated in Area 2
2:00 P.M. Skin irradiated in Area 3
3:30 P.M. Skin irradiated in Area 4
4:00 P.M. 10 cc. of trypan blue given intravenously
4:05 P.M. Skin irradiated in Area 5
4:13 P.M. Trypan blue in Area 5
4:45 P.M. The skin in Areas 5 and 3 are blue. The largest amount of dye is in Area 5. Areas 1, 2 and 4 do not show any more dye than there is in the untreated skin.

Pathological Lesions in the Skin of Rabbits Following Recent Irradiation with Roentgen Rays.

Twenty of the rabbits used in the experiment to study the localization and concentration of trypan blue were killed. The irradiated areas of skin were studied histologically. The observations recorded below are based upon the study of 48 sections of skin removed at the following intervals after seven and a half minutes of irradiation: immediately, 5; thirty minutes, 10; sixty minutes, 5; ninety minutes, 5; two hours, 10; three hours, 5; four hours, 3; eighteen hours, 12.

Polymorphonuclear leukocytes are present in

TABLE I

LOCALIZATION AND CONCENTRATION OF TRYPAN BLUE IN AREAS OF SKIN IRRADIATED WITH ROENTGEN RAYS*

Rabbit No.	Interval Between the Irradiation of Skin and Injection of Dye									
	7 hr.	6 hr.	5 hr.	4 hr.	3 hr.	2 hr.	1.5 hr.	1 hr.	30 min.	0 min.
86 kv. (peak), 5 ma., 10 min. at 20 cm. target-skin distance (2,720 r)										
677	–	–	–	–	o	o	–	+	–	o
678	–	–	–	–	o	o	–	+	–	o
680	–	–	–	–	o	o	–	+	–	o
86 kv. (peak), 5 ma., 7½ min. at 20 cm. target-skin distance (2,040 r)										
652	–	–	–	o	o	o	–	+	–	o
653	–	–	–	o	o	o	–	+	–	o
654	–	–	–	o	o	o	–	o	–	+
655	–	–	–	o	o	o	–	+	–	o
922	–	–	–	–	o	o	–	+	–	o
923	–	–	–	–	o	o	–	+	–	o
924	–	–	–	–	o	o	–	o	–	o
925	–	–	–	–	o	o	–	+	–	o
X-1	–	–	–	–	–	–	–	o	o	–
X-2	–	–	–	–	–	–	–	o	o	–
X-3	–	–	–	–	–	–	–	+	+	–
X-4	–	–	–	–	–	–	–	+	+	–
X-5	–	–	–	–	–	o	o	o	o	o
X-6	–	–	–	–	–	o	o	+	o	o
X-7	–	–	–	–	–	o	o	+	o	o
86 kv. (peak), 5 ma., 5 min. at 20 cm. target-skin distance (1,360 r)										
630	o	o	o	o	o	+	–	+	–	o
631	o	o	o	o	o	+	–	+	–	o
632	o	o	o	o	o	+	–	+	–	o
633	o	o	o	o	o	o	–	?	–	o
634	o	o	o	o	o	?	–	+	–	o
635	o	o	o	o	o	?	–	o	–	o
X-1	–	–	–	–	–	–	–	o	o	–
X-2	–	–	–	–	–	–	–	o	o	–
X-3	–	–	–	–	–	–	–	+	o	–
X-4	–	–	–	–	–	–	–	+	o	–
86 kv. (peak), 5 ma., 2½ min. at 20 cm. target-skin distance (680 r)										
X-1	–	–	–	–	–	–	–	o	o	–
X-2	–	–	–	–	–	–	–	o	o	–
X-3	–	–	–	–	–	–	–	+	+	–
X-4	–	–	–	–	–	–	–	+	+	–

* = 272 r per minute.
+ = Dye present in area irradiated.
o = No dye present in area irradiated.
– = No irradiation applied.

TABLE II

LOCALIZATION AND CONCENTRATION OF TRYPAN BLUE IN IRRADIATED AREAS OF RABBITS' SKIN

Rabbit No.	Interval Between the Irradiation of Skin and Injection of Dye						
	21 hr.	18 hr.	3 hr.	2 hr.	1 hr.	30 min.	0 min.*
995	−	−	0	0	+	0	+
996	−	−	0	0	+	0	+
997	−	−	0	0	+	0	+
1002	0	−	−	0	+	0	+
1003	0	−	−	0	+	0	0
1024	−	0	−	0	+	0	0
1025	−	0	−	0	+	0	0
1026	−	0	−	0	+	0	+
1031	−	0	−	0	+	0	0
1033	−	0	−	0	+	0	0
1078	−	−	−	−	+	+	+
1079	−	−	−	−	+	0	0
1080	−	−	−	−	+	0	0
1081	−	−	−	−	+	+	+
Total Observations	2	5	3	10	14	14	14
+	0	0	0	0	14	2	7
−	2	5	3	10	0	12	7

* The dye was injected immediately before the last area of skin was irradiated.

+ = Dye present; 0 = No dye; − = No irradiation.

The skin of these rabbits was irradiated for 7½ minutes, 86 kv. (peak), 5 ma.at 20 cm. target-skin distance (2,040 r at the rate of 272 r per minute).

the corium within an hour following irradiation (Fig. 1). The number of these cells apparently increase during the next three to four hours. These leukocytes infiltrated not only the corium but in some of the rabbits they were present in the cutaneous maximum muscle. The lumen of the small blood vessels was filled with leukocytes and large numbers of these cells surrounded the vessels. Eighteen hours following this irradiation there were fewer leukocytes present in the corium than during the first four hours.

The nuclei of the connective tissue cells in the corium are frequently swollen and apparently stain more deeply with hematoxylin than the cells in the untreated areas of skin. Vacuoles are present in the cytoplasm of some of these cells. There are no pathological changes observed in the endothelial cells of the small blood vessels. It is rare to find a pyknotic cell in the epidermis within a period of eighteen hours following irradiation. Four sections removed from one rabbit six days following the irradiation show a few pyknotic cells in the

TABLE III

INTERVAL IN WHICH TRYPAN BLUE LOCALIZES AND CONCENTRATES IN AREAS OF IRRADIATED SKIN*

Interval†	Localization of Trypan Blue			Total Number of Observations
	Positive	Negative	Questionable	
0 min.	8	26	0	34
30 min.	6	23	0	29
60 min.	35	10	1	46
90 min.	0	3	0	3
2 hr.	3	25	2	30
3 hr.	0	23	0	23
4 hr.	0	10	0	10
5 hr.	0	6	0	6
6 hr.	0	6	0	6
7 hr.	0	6	0	6
18 hr.	0	5	0	5
21 hr.	0	2	0	2

* These data include all irradiated areas irrespective of the length of time of the exposure.

† Time between the irradiation of the skin and the intravenous injection of trypan blue.

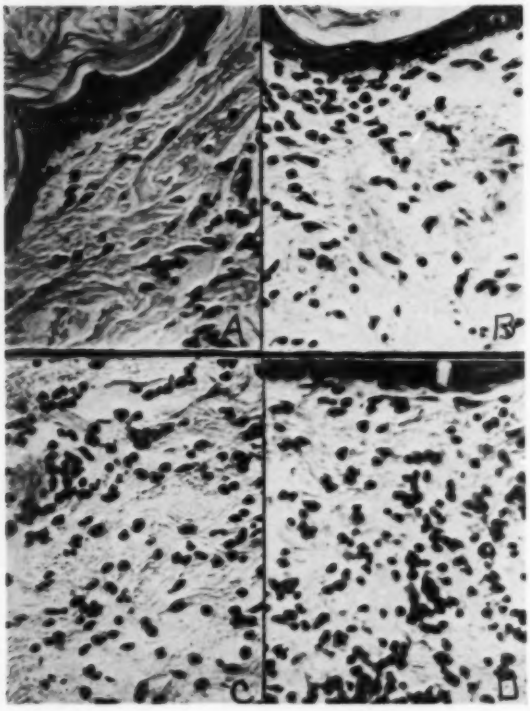

FIG. 1. Rabbit No. 923. Polymorphonuclear leukocytes infiltrate the corium following roentgen irradiation (86 kv., peak, 5 ma., 7½ min. at 20 cm. target-skin distance). Note the increase in number of leukocytes during the first three hours following irradiation. There are essentially no leukocytes in the corium (*A*) thirty minutes after the area was irradiated. This rabbit was given 2,040 r at the rate of 272 r per minute. *B*, section removed sixty minutes after irradiation; *C*, section removed two hours after irradiation; *D*, section removed three hours after irradiation.

epidermis. The nuclei of the connective tissue cells in the corium appear more compact than normal and also appear to stain more deeply with hematoxylin. The cells in the epidermis do not show any evidence of hyperplasia six days following irradiation.

DISCUSSION

These experiments show that trypan blue, following an intravenous injection, localizes and concentrates in areas of the rabbits' skin treated with roentgen rays only during specific intervals. Trypan blue localizes and concentrates in the skin when it is injected either immediately before or immediately after the area is irradiated. This dye also localizes and concentrates in areas of skin irradiated one hour previous to the injection of the dye. There is an interval, therefore, between immediately and one hour and after two hours in which trypan blue does not localize and concentrate in areas of skin even in the same rabbit treated with the same amount of radiation. The dye frequently localizes within thirty minutes and usually within a period of ten minutes after it is injected intravenously.

The frequency with which the dye localizes and concentrates in the areas, irradiated an hour before the dye is injected, is greater than that occurring in the areas irradiated either immediately before or immediately after the injection of the dye. It appears that the frequency with which this reaction occurs in irradiated areas of skin is significant. The observation that this colloidal dye, following an intravenous injection, localizes and concentrates in the skin indicates that the permeability of the cells in the skin of the rabbit is affected immediately by irradiation. Variations in the permeability of the cells following irradiation is discussed in a review by Warren.[3] It appears, however, from Warren's work that the demonstration of the time in which these changes in permeability appear in our studies is much earlier than those of other investigators.

This demonstration of a localization and a concentration of trypan blue in areas of skin irradiated either immediately before, immediately afterwards or during the time of irradiation is interesting in view of MacKee's[6] recent statement that "except in the case of very intense irradiation, no immediate effect is observed in the cell. After a longer or shorter period changes begin to take place." The quantity of radiation used in these experiments is of course large as compared with that used in humans; however, the macroscopic changes in the skin of the rabbit are minimal.

It is well known that there is an increase in hydrogen ion concentration following irradiation. This may be very transitory in some tissues.[6] Physiological changes in cells

have been explained by electrons ionizing atoms that may be in their path.

The ionized atom is temporarily in an abnormal condition, and while in this state, it lends itself readily to entering into new combinations. Ionization of the individual atom lasts only a very short time. If, however, enough of them are ionized simultaneously, a large enough percentage of the cell constituents may undergo transformation so that an apparent change is produced.[6]

It is interesting to observe an interval of one hour in which trypan blue fails to localize and to concentrate in irradiated areas of skin. It has been suggested in other studies that this dye localizes and concentrates in the skin as a result of a change in the metabolism of the cells.[12] This disturbance in the metabolism of the cell apparently may occur in the cells of the skin immediately following irradiation and it remains for only a very short period as indicated by the localization and concentration of trypan blue. One hour later a second reaction occurs in the cells which permits the localization and the concentration of the dye. This second reaction likewise remains only during a short interval as indicated by the failure of trypan blue to localize and to concentrate in areas of skin irradiated three hours or longer before the dye is injected.

The immediate change that occurs in the skin of the rabbit may be explained by the phenomena discussed above. The mechanism of the localization and concentration of trypan blue in areas of skin irradiated one hour previously apparently may result also from a disturbance in the metabolism of the cells, however, this is the result of a delayed reaction of the irradiation on the cell.

Rudisill and Hoch[14] in 1938 made some interesting observations on the mechanism of the effect of roentgen irradiation on cells. These investigators assumed that the respiration of the cell (respiration as used here signifies all the energy yielding reactions of the cell) could be injured by irradiation.

Cellular respiration is carried on through reduction-oxidation reactions. . . . cellular damage resulting from x-rays shows a latent period and autocatalytic reactions likewise exhibit a preliminary lag phase. . . . it seems logical to assume that the autocatalytic mechanisms governing the redox [reduction-oxidation reactions] equilibria are affected by x-rays.

The effect of roentgen irradiation on the redox system was studied by determining the time necessary for the reappearance of the cytochrome C absorption band in the visible spectrum following oxygenation. Yeast cells were used for this study.

. . . the cytochrome C band did not reappear after oxygenation until from three and three-fourths to five and one-half minutes had elapsed, an average initial increase of 225 per cent. This we interpret as signifying definite although not irreparable damage to the dehydrogenase complex. This transitory nature of this effect indicates the ability of the injured cells to recover and but serves to emphasize the fundamental protoplasmic property of repair in the living organism. . . . the biological effects of x-rays on cells may result from inactivation or destruction of cell respiratory mechanisms through the effects of these substances on the co-catalysts of the dehydrogenases.

The ability of an irradiated cell to recover from sub-lethal exposure to x-rays is to be found in its ability to elaborate more catalyst to replace that which was inactivated, and to do it rapidly enough to meet its own particular respiratory requirements.

The delayed lethal action of x-rays on cells (latent period) finds explanation in the fact that the reaction chain involved contains autocatalysts. (Rudisill and Hoch[14].)

The observations, as recorded in the present experiment on the time that trypan blue localizes and concentrates in areas of rabbit's skin, indicate that the effect of the irradiation may be manifest within a period of only a very few minutes. This biological effect like that observed by Rudisill and Hoch in yeast occurs immediately and is transient. This apparently is an indication of the ability of the cells in the skin of the rabbit to recover rapidly from the injury produced by this amount of radiation.

Several recent observers have reviewed and discussed the effect of irradiation on the skin.[2,3,8] There appears to be some variation in the effect of irradiation on this tissue especially with regard to the cellular reactions and the mechanism of the action of irradiation on inflammation. The most conspicuous variation from the normal observed in this experiment is the presence of polymorphonuclear leukocytes in the corium. These cells are present in the tissues after approximately sixty minutes. They usually increase in number during the following five hours. The rapidity with which polymorphonuclear leukocytes concentrate in the corium following irradiation is interesting when one considers the possible mode of action of roentgen rays on acute local infections. The significant rôle of the polymorphonuclear leukocytes in the phagocytosis of certain bacteria is well established. A rapid concentration of leukocytes about foci of bacteria apparently will permit an increase in the rate of phagocytosis of the bacteria and probably permit a more rapid localization and destruction of the organisms.

The absence of any histological changes in the epithelial cells and blood vessels in the corium of these animals may be accounted for by the short interval between the time of irradiation and the time in which the sections are removed. Rottmann[13] states that,

> Changes demonstrable microscopically can be found in the skin of subjects a few hours after the irradiation when borderline erythema is barely beginning macroscopically. . . . The changes in the epidermis consist of edema of the cells and nuclei, vacuolization and contraction of the nuclei. There were granular changes in the stratum granulosum which on giving three erythema doses could also be seen in spots in the upper cell layers. There were always vessel changes in the corium: swelling of the endothelium, great changes in the adventitia cells, perivascular cell infiltration, chiefly lymphocytes, fewer leucocytes.

Pohle and Bunting[9] have described in detail the histological changes occurring in the skin of rats, beginning twenty-four hours after irradiation.

There is no relation, as far as we have determined, between the time that trypan blue localizes and concentrates in areas of skin treated with 2,040 r at the rate of 272 r per minute (86 kv., peak, with no filter), and the time in which polymorphonuclear leukocytes localize in the same area. In previous studies on capillary permeability and inflammation one of us also has failed to demonstrate a correlation between these two phenomena.[12]

It has been suggested that an increase in capillary permeability occurs in areas of inflammation as a result of a disturbance in the ratio of calcium, phosphorus and potassium in the cell.[12] Adler and Adler[1] think that there is a fall in the calcium and potassium content of the skin with an increasing dose of roentgen rays. Lieber[5] has expressed the opinion that a disturbance in the physiochemical equilibrium of potassium and calcium is enough to account for a disturbed function in the affected cells. Henschen and Becker's[4] observation that irradiation produces an alkalosis in the treated skin may be a significant finding in view of Menkin's[7] demonstration that the type of cells occurring in areas of inflammation is determined by the hydrogen ion concentration. Polymorphonuclear leukocytes are found in alkaline environment and lymphocytes occur more frequently in an acid medium.

SUMMARY

A change occurs in the skin of the rabbit immediately following irradiation with roentgen rays as shown by the localization and the concentration of trypan blue following an intravenous injection of the dye. The time is brief during which this dye localizes and concentrates in these areas. It is suggested that this localization and concentration of dye results from a change in the permeability of the cells as produced by the irradiation. Areas of skin treated with a similar quantity of radiation one hour previously likewise become blue fol-

lowing the injection of the dye. Areas of skin treated with the same amount of radiation three hours or longer before the dye is injected do not show any more dye than the untreated areas of skin.

Polymorphonuclear leukocytes are present in the corium of the irradiated skin after approximately sixty minutes. The number of these cells increases during the following several hours. There is no correlation between the time in which trypan blue localizes and concentrates in areas of irradiated skin and the time in which polymorphonuclear leukocytes infiltrate the corium in the same area.

The mechanism for the increase in capillary permeability following irradiation is discussed.

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THE AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY

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Twenty-eighth Annual Meeting: 1943, to be announced.

EDITORIAL

ROENTGENOLOGIC EXAMINATION AND, NOT OR, GASTROSCOPY*

ALMOST every diagnostic procedure of major importance that has passed its initial tests follows a familiar cycle. At first the new method is accredited both with capabilities and with limitations that it does not possess, for its enthusiastic proponents are inclined to imagine vain things, and practitioners of the old ways are prone to regard the new with extreme doubt. Neither attitude is unnatural or blameworthy, for imagination is essential to progress, and, on the other hand, without a healthy degree of skepticism real progress often would suffer from imposture. Not rarely, however, the rivalry between believers and doubters degenerates into an academic hostility that is both foolish and futile. Whether this occurs or not, the new procedure continues in its cycle of evolution and eventually finds its proper place. Usually it fails to fulfill the extravagant expectations of its early advocates, but often it proves eventually to be remarkably efficient in ways that had not been foreseen. Occasionally it supersedes, but far more often it supplements, an older test, so that old controversies arising from fancied competition usually are made to appear ridiculous. In short, the final status of the method is determined, not by early impressions and predictions, but by the results of long and thorough trial.

Many of you here today witnessed the transit of the roentgenologic method through a cycle of this sort. At the beginning its immediate capabilities were greatly overestimated, for it was rather widely supposed that the diagnosis of virtually all internal diseases would soon be effected by simple roentgenoscopy and roentgenography. Disappointment followed, of course, and only after many years did the roentgenologic diagnosis of internal disease in general and of abdominal affections in particular become really efficient. Then it seemed for a time that other methods of investigation might be supplanted, but although the scope and reliability of roentgenologic diagnosis have continued to increase, the anamnesis, physical examination and laboratory tests have not been discarded or even curtailed.

That gastroscopy is following a comparable pattern is rather obvious. The procedure has matured sufficiently to be adopted into the medical armamentarium but is still young enough that estimates of its value are bound to vary. I am willing to offer a brief appraisal and even to compare certain merits of gastroscopy with those of roentgenologic examination, but only with the understanding that my opinions are based solely on present common achievements by both procedures and not on extraordinary accomplishments or future potentialities of either method.

Sometimes superiority of either gastroscopy or roentgenologic examination is claimed on the ground that in specific instances one method disclosed a lesion which the other had failed to reveal. That kind of comparison is insidious and unfair, for, aside from disease in certain areas of the stomach that are not accessible to gastroscopic inspection, any gastric lesion that would be visible macroscopically should be found by either method, and all failures should be charged to the examiner and not to the mode of examination. If gastroscopy must be compared with roentgenologic ex-

* Presented at the Forty-third Annual Meeting, American Roentgen Ray Society, Chicago, Ill., Sept. 15–18, 1942.

amination, there are, I think, at least two particulars in which gastroscopy excels: namely, in establishing diagnoses of gastritis and in determining decisively whether or not gastric ulcers have healed or are in process of healing.

In Europe before the outbreak of the present war, considerable advances had been made in the roentgenologic diagnosis of gastritis, and a few roentgenologists had become proficient in identifying the disease. In this country, it seems to me, progress in the recognition of gastritis has been slow, perhaps partly because of lingering uncertainties as to the pathology, varieties, clinical significance and distinguishing marks of the disease. Ulcerative gastritis can be identified definitely, and frequently the signs of hypertrophic gastritis are strongly suggestive but in most cases of the hypertrophic variety and all of the atrophic form the roentgenologic picture is either inconclusive or completely negative, for it may be imitated closely by purely physiologic alteration of the mucosal relief. My gastroscopic colleagues, however, can identify gastritis of any variety almost unerringly, and it is my custom to request their aid in any case in which the existence of the disease seems likely.

It has been claimed by some authors also that the differential diagnosis of benign from malignant ulcer, regardless of the factor of healing, can be made more reliably with the gastroscope than with roentgen rays. I am inclined to doubt this claim, for when malignancy is not roentgenologically evident it is not usually evident on direct macroscopic inspection. But I shall not emphasize this doubt, for I realize that small ulcerating carcinomas, diagnosed roentgenologically as such, often are indistinguishable from simple ulcer on inspection of the excised specimen. Like roentgenologic examination, gastroscopy deals with living tissues, not specimens, and gastroscopy has a further advantage in being able to see lesions in their true color, whereas roentgen rays depict them only in black and white

But roentgenologic examination also has advantages. They are so numerous and so familiar to you that I forbear listing them.

The efficiency of each method keeps both on their toes—each has its advantages but it is not fair to foster the notion that the two methods are competitive and antagonistic. On the contrary, they are complementary and cooperative. It is not a question of roentgenologic examination *or* gastroscopy but of roentgenologic examination *and* gastroscopy in any case in which either method is likely to elicit significant data that the other procedure failed to disclose.

B. R. KIRKLIN

SOCIETY PROCEEDINGS, CORRESPONDENCE AND NEWS ITEMS

Items for this section solicited promptly after the events to which they refer.

MEETINGS OF ROENTGEN SOCIETIES*

United States of America

American Roentgen Ray Society
Secretary, Dr. H. Dabney Kerr, University Hospital, Iowa City, Iowa. Annual Meeting: 1943, to be announced.

American College of Radiology
Secretary, Mac F. Cahal, 540 N. Michigan Ave., Chicago, Ill. Annual meeting: 1943, to be announced.

Section on Radiology, American Medical Association
Secretary, Dr. J. T. Murphy, 421 Michigan St., Toledo, Ohio. Annual meeting: 1943, cancelled.

Arkansas Radiological Society
Secretary, Dr. J. S. Wilson, Mack Wilson Hospital, Monticello, Ark. Meets every three months and also at time and place of State Medical Association.

Radiological Society of North America
Secretary, Dr. D. S. Childs, 607 Medical Arts Bldg., Syracuse, N. Y. Annual meeting: 1943, to be announced.

Radiological Section, Baltimore Medical Society
Secretary, Dr. Walter L. Kilby, Baltimore. Meets third Tuesday each month, September to May.

Section on Radiology, California Medical Association
Secretary, Dr. J. D. Coate, 434 Thirtieth St., Oakland, Calif.

Radiological Section, Connecticut Medical Society
Secretary, Dr. Max Climan, 242 Trumbull St., Hartford, Conn. Meets bi-monthly on second Thursday, at place selected by Secretary. Annual meeting in May.

Section on Radiology, Illinois State Medical Society
Secretary, Dr. H. W. Ackemann, 321 W. State St., Rockford, Ill.

Radiological Section, Los Angeles County Medical Association
Secretary, Dr. Donald R. Laing, 65 North Madison Ave., Pasadena, Calif. Meets on second Wednesday of each month at the County Society Building.

Radiological Section, Southern Medical Association
Secretary, Dr. Roy G. Giles, Temple, Texas.

Brooklyn Roentgen Ray Society
Secretary, Dr. Leo Harrington, 880 Ocean Ave., Brooklyn, N. Y. Meets monthly on fourth Tuesday, October to April.

Buffalo Radiological Society
Secretary, Dr. Joseph S. Gian-Francheschi, 610 Niagara St., Buffalo, N. Y. Meets second Monday of each month except during summer months.

Chicago Roentgen Society
Secretary, Dr. Warren W. Furey, 6844 S. Oglesby Ave., Chicago, Ill. Meets second Thursday of each month October to April inclusive at the Palmer House.

Cincinnati Radiological Society
Secretary, Dr. Samuel Brown, 707 Race St., Cincinnati, Ohio. Meets third Tuesday of each month, October to May, inclusive.

Cleveland Radiological Society
Secretary, Dr. J. O. Newton, 13921 Terrace Rd., East Cleveland. Meets at 6:30 P.M. at Midday Club on fourth Monday each month, October to April, inclusive.

Denver Radiological Club
Secretary, Dr. Edward J. Meister, 366 Metropolitan Bldg., Denver, Colo. Meets third Friday of each month at Denver Athletic Club.

Detroit Roentgen Ray and Radium Society
Secretary, Dr. E. R. Witwer, Harper Hospital. Meets monthly on first Thursday from October to May, at Wayne County Building.

Florida Radiological Society
Acting Secretary, Dr. Walter A. Weed, 204 Exchange Bldg., Orlando, Fla. Meetings in May and November.

Georgia Radiological Society
Secretary, Dr. James J. Clark, 478 Peachtree St., Atlanta, Ga. Meets in November and at annual meeting of Medical Association of Georgia in the spring.

Radiological Society of Kansas City
Secretary, Dr. Arthur B. Smith, 800 Argyle Bldg., Kansas City, Mo. Meets third Thursday of each month at a place designated by the president.

Illinois Radiological Society
Secretary, Dr. Wm. DeHollander, St. John's Hospital, Springfield, Ill. Meets three times a year.

Indiana Roentgen Society
Secretary, Dr. H. C. Ochsner, Methodist Hospital, Indianapolis. Meeting held the second Sunday in May annually.

Kentucky Radiological Society
Secretary, Dr. W. C. Martin, 321 W. Broadway, Louisville. Meets annually in Louisville on first Saturday in April.

Long Island Radiological Society
Secretary, Dr. Marcus Wiener, 1430-48th St., Brooklyn, N. Y. Meets Kings County Med. Soc. Bldg. monthly on fourth Thursday, October to May, 8:30 P.M.

Louisiana Radiological Society
Secretary, Dr. J. R. Anderson, 1130 Louisiana Ave., Shreveport. Meets annually during Louisiana State Medical Society Meeting.

Michigan Association of Roentgenologists
Secretary, Dr. E. M. Shebesta, 1429 David Whitney Bldg., Detroit. Three meetings a year, Fall, Winter, Spring.

Milwaukee Roentgen Ray Society
Secretary, Dr. C. A. H. Fortier, 231 W. Wisconsin Ave., Milwaukee, Wis. Meets monthly on second Monday at University Club.

Minnesota Radiological Society
Secretary, Dr. J. P. Medelman, 572 Lowry Medical Arts Bldg., St. Paul.

Nebraska Radiological Society
Secretary, Dr. D. A. Dowell, Medical Arts Bldg., Omaha, Nebr. Meets third Wednesday of each month, at 6 P.M. at either Omaha or Lincoln.

New England Roentgen Ray Society
Secretary, Dr. Hugh F. Hare, Lahey Clinic, Boston, Mass. Meets monthly on third Friday, Boston Medical Library.

Radiological Society of New Jersey
Secretary, Dr. H. J. Perlberg, 921 Bergen Ave., Jersey City. Meets annually at time and place of State Medical Society. Mid-year meetings at place chosen by president.

New York Roentgen Society
Secretary, Dr. M. M. Pomeranz, 1020 Park Ave., New York City. Meets monthly on third Monday, New York Academy of Medicine, at 8:00 P.M.

North Carolina Roentgen Ray Society
Secretary, Dr. Major Fleming, Rocky Mount, N. C. Annual meeting at time and place of State Medical Society. Mid-year scientific meeting at place designated.

North Dakota Radiological Society
Secretary, Dr. L. A. Nash, St. John's Hospital, Fargo. Meetings held by announcement.

Central New York Roentgen Ray Society
Secretary, Dr. C. F. Potter, 820 S. Crouse Ave., Syracuse. Three meetings a year. January, May, November.

* Secretaries of Societies not here listed are requested to send the necessary information to the Editor.

OHIO RADIOLOGICAL SOCIETY
Secretary, Dr. J. E. McCarthy, 707 Race St., Cincinnati. Meets at time and place of annual meeting of Ohio State Medical Association.

PACIFIC ROENTGEN SOCIETY
Secretary, Dr. L. H. Garland, 450 Sutter St., San Francisco, Calif. Meets annually, during meeting of California Medical Association.

PENNSYLVANIA RADIOLOGICAL SOCIETY
Secretary, Dr. L. E. Wurster, 416 Pine St., Williamsport.

PHILADELPHIA ROENTGEN RAY SOCIETY
Secretary, Dr. R. P. Barden, University Hospital. Meetings first Thursday of each month from October to May inclusive at 8:15 P.M., in Thompson Hall, College of Physicians, 19 S. 22d St.

PITTSBURGH ROENTGEN SOCIETY
Secretary, Dr. R. G. Alley, 4800 Friendship Ave. Meets second Wednesday each month, 4:30 P.M., October to June, Pittsburgh Academy of Medicine.

ROCHESTER ROENTGEN RAY SOCIETY, ROCHESTER, N. Y.
Secretary, Dr. Sidney Larson, Strong Memorial Hospital. Meets monthly on third Monday from October to May, inclusive, 8 P.M. at Strong Memorial Hospital.

ROCKY MOUNTAIN RADIOLOGICAL SOCIETY
Secretary, Dr. A. M. Popma, 220 N. First St., Boise, Idaho.

ST. LOUIS SOCIETY OF RADIOLOGISTS
Secretary, Dr. W. K. Mueller, University Club Bldg. Meets fourth Wednesday of each month, except June, July, August, and September, at a place designated by the president.

SAN FRANCISCO RADIOLOGICAL SOCIETY
Secretary, Dr. H. A. Hill, 450 Sutter St., San Francisco. Meets monthly on third Thursday at 7:45 P.M., first six months at Toland Hall, second at Lane Hall.

SOUTH CAROLINA X-RAY SOCIETY
Secretary, Dr. T. A. Pitts, Baptist Hospital, Columbia, S. C. Meets in Charleston on first Thursday in November, also at the time and place of South Carolina State Medical Association.

TENNESSEE RADIOLOGICAL SOCIETY
Secretary, Dr. J. M. Frère, 707 Walnut St., Chattanooga, Tenn. Meets annually at the time and place of the Tennessee State Medical Association.

TEXAS RADIOLOGICAL SOCIETY
Secretary, Dr. Herman Klapproth, Sherman, Texas.

UNIVERSITY OF MICHIGAN DEPARTMENT OF ROENTGENOLOGY STAFF MEETING
Meets each Monday evening from September to June, at 7 P.M. at University Hospital.

UNIVERSITY OF WISCONSIN RADIOLOGICAL CONFERENCE
Secretary, Dr. E. A. Pohle, 1300 University Ave., Madison, Wis. Meets every Thursday from 4:00–5:00 P.M., Room 301, Service Memorial Institute.

VIRGINIA RADIOLOGICAL SOCIETY
Secretary, Dr. E. L. Flanagan, 116 E. Franklin St., Richmond, Va. Meets annually in October.

WASHINGTON STATE RADIOLOGICAL SOCIETY
Secretary, Dr. K. J. Holtz, American Bank Bldg., Seattle. Meets fourth Monday each month, College Club, Seattle.

X-RAY STUDY CLUB OF SAN FRANCISCO
Secretary, Dr. J. M. Robinson, University of California Hospital. Meets monthly in evening on third Thursday.

CUBA

SOCIEDAD DE RADIOLOGÍA Y FISIOTERAPIA DE CUBA
President, Dr. J. Manuel Viamonte, Hospital Mercedes, Habana, Cuba. Meets monthly in Habana.

BRITISH EMPIRE

BRITISH INSTITUTE OF RADIOLOGY INCORPORATED WITH THE RÖNTGEN SOCIETY
Meets monthly on third Thursday from November to June inclusive, at 8:15 P.M., 32 Welbeck St., London.

SECTION OF RADIOLOGY OF THE ROYAL SOCIETY OF MEDICINE (CONFINED TO MEDICAL MEMBERS)
Meets on the third Friday of each month during the winter at 8:15 P.M. at the Royal Society of Medicine 1, Wimpole St., London, W. 1.

FACULTY OF RADIOLOGISTS
Secretary, Dr. M. H. Jupe, 32 Welbeck St., London, W. 1 England.

SECTION OF RADIOLOGY AND MEDICAL ELECTRICITY, AUSTRALASIAN MEDICAL CONGRESS
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RADIOLOGICAL SECTION OF THE VICTORIAN BRANCH OF THE BRITISH MEDICAL ASSOCIATION
Secretary, Dr. Keith Hallam, St. George's Hospital, K.E.W., Melbourne, E. 4, Victoria, Australia. Meets monthly from March to November inclusive.

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RADIOLOGICAL SECTION, NEW ZEALAND BRITISH MEDICAL ASSOCIATION
Secretary, Dr. Colin Anderson, Invercargill, New Zealand. Meets annually.

CONTINENTAL EUROPE

SOCIEDAD ESPANOLA DE RADIOLOGIA Y ELECTROLOGIA
Secretary, Dr. J. Martin-Crespo, Fuencarral, 7. Madrid, Spain. Meets monthly in Madrid.

SOCIÉTÉ SUISSE DE RADIOLOGIE (SCHWEIZERISCHE RÖNTGEN-GESELLSCHAFT)
Secretary for French language, Dr. A. Grosjean La Chaux de Fonds.
Secreatry for German language, Dr. Scheurer, Molzgasse Biel. Meets annually in different cities.

SOCIETATEA ROMANA DE RADIOLOGIE SI ELECTROLOGIE
Secretary, Dr. Oscar Meller, Str. Banul Mărăcine, 30, S. I., Bucuresti, Roumania. Meets second Monday in every month with the exception of July and August.

ALL-RUSSIAN ROENTGEN RAY ASSOCIATION, LENINGRAD: USSR in the State Institute of Roentgenology and Radiology, 6 Roentgen St.
Secretaries, Drs. S. A. Reinberg and S. G. Simonson. Meets annually.

LENINGRAD ROENTGEN RAY SOCIETY
Secretaries, Drs. S. G. Simonson and G. A. Gusterin. Meets monthly, first Monday at 8 o'clock, State Institute of Roentgenology and Radiology, Leningrad.

MOSCOW ROENTGEN RAY SOCIETY
Secretaries, Drs. L. L. Holst, A. W. Ssamygin and S. T. Konobejevsky. Meets monthly, first Monday, 8 P.M.

SCANDINAVIAN ROENTGEN SOCIETIES
The Scandinavian roentgen societies have formed a joint association called the Northern Association for Medical Radiology, meeting every second year in the different countries belonging to the Association.

URGENT NEED OF CONSERVING ROENTGEN-RAY EQUIPMENT AND ACCESSORIES

Most civilian radiologists are aware that it is becoming increasingly difficult to obtain roentgen-ray accessories, but the gravity of the situation and the necessity of taking steps to meet it are not fully appreciated. Among items in which the shortage is already severe or threatens to become so are: cassettes, intensifying screens, developing hangers, developing tanks, roentgen tubes, roentgen-ray meters and film driers. Most critical is the scarcity of developing hangers, which are almost unobtainable, and of intensifying screens.

Chief among causes of the condition is, of course, the tremendous demands of our armed forces. Priorities have vastly reduced available stocks of essential materials, notably steel and especially stainless steel. To this circumstance is added the fact that many of the skilled artisans who are indispensable for the manufacture of roentgenologic apparatus have been inducted into the armed services, and production is correspondingly diminished.

It seems unlikely that the condition will be relieved soon or in substantial degree by governmental action, for the government must place the welfare of its fighting men above all other considerations, and all of us heartily approve of that obligation. As radiologists we must make the best of the situation by conserving the equipment we have and using it wherever it is most needed. Our past prodigality has left a wide margin for retrenchment and economy without serious loss of efficiency. Damaged equipment can be repaired. Outmoded accessories can be redeemed from private junk heaps and used again if needed. All apparatus can be handled with greater care and used only when really necessary. Equipment left behind by physicians who have joined the armed forces can be sold or loaned to civilian radiologists and put into useful service. These are only a few of the measures that we can employ, and, if we apply ourselves earnestly to this task, we can accomplish much by efforts and sacrifices that will be very small in comparison with those made by our fighting kinsmen and colleagues.

Military Committee
A. C. Christie, *Chairman*
W. Edward Chamberlain
E. P. Pendergrass
U. V. Portmann
B. R. Kirklin, *Secretary*

SCIENCE BUILDING NAMED IN HONOR OF DR. PFAHLER

During Founders' Day Convocation, on October 13, 1942, at Ursinus College, Collegeville, Pennsylvania, the beautiful new science building was named the Pfahler Hall of Science in honor of Dr. George E. Pfahler, a pioneer radiologist, who has devoted his professional life to the use of roentgen rays and radium in medicine and whose attainments are well known to all radiologists. He has been a member of the Board of Directors of Ursinus College since 1935. A portrait of Dr. Pfahler was unveiled during these special exercises and was presented to the College by Mrs. Pfahler. It is the work of Mr. Robert Susan and hangs in the foyer of the Pfahler Hall of Science. The principal address during the exercises was given by Dr. William D. Coolidge, Vice-President and Director of Research for the General Electric Company of Schenectady, New York, the title being "The Rôle of Science Institutions in our Civilization."

THE RADIOLOGICAL RESEARCH LABORATORY OF COLUMBIA UNIVERSITY

The establishment of a Radiological Research Laboratory in connection with the cancer research program of Columbia University is announced by Dr. Willard C. Rappleye, dean of the faculty of medicine. Dr. Rappleye said:

> The research in the laboratory will be mainly concerned with the study of the effect of radiation on living cells and the possibilities of altering resistance to radiation and to the introduction of chemical and

endocrine substances that might conceivably have some bearing on the problem of cancer.

Special attention will be given to setting up a satisfactory program of deep therapy treatment in which high voltage x-rays are used to penetrate deeply into the tissues and destroy cancer. A million volt therapy machine will be installed in the Presbyterian Hospital in connection with the plan.

In addition to research in radiology, experiments will be carried on in the fields of chemistry, immunology, endocrinology and biology. The program represents an effort to develop real authorities on cancer, of whom there are very few. Research will go beyond the ordinary hospital work and will be more of an experimental nature.

Dr. Gioacchino Failla, physicist at the Memorial Hospital, has been appointed director of the laboratory. Dr. Edith H. Quimby, associate physicist at the Memorial Hospital, and Dr. Titus C. Evans, assistant professor of radiology at the State University of Iowa, will be his associates.—*Science*, Dec. 11, 1942, *96*, 533.

GEORGIA RADIOLOGICAL SOCIETY

The annual meeting of the Georgia Radiological Society was held at Lawson General Hospital, Atlanta, in November, 1942. An excellent program was given. The Orthopedic Department, under Colonel Sloat, presented and illustrated many interesting orthopedic cases. Luncheon was served at the Officers Mess. The afternoon program consisted of a paper on "Malignant Lesions of the Mouth," by Dr. Elliott Scarborough, after which discussion of unusual and interesting case reports was taken up The officers of the Society are: *President*, Dr R. C. Pendergrass, Americus; *Secretary-Treasurer*, Dr. James J. Clark, Atlanta.

VIRGINIA RADIOLOGICAL SOCIETY

At a recent meeting of the Virginia Radiological Society the following officers were elected: *President*, Dr. Wright Clarkson, Petersburg; *Vice-President*, Dr. Clayton W. Eley, Norfolk; *Secretary-Treasurer*, Dr. E. Latané Flanagan, Richmond.

CORRECTION

In a paper by M. T. Koven, Bernard E. Epstein, and Max Kulick, entitled "A device to aid in positioning for lateral roentgenograms of the femoral neck," and published in the October, 1942, issue of the JOURNAL, Vol. 48, pages 554–556, the last sentence in the legend of Figure 1 reads as follows: "Note that the thigh is held in slight external rotation." This should read: "Note that the thigh is held in slight internal rotation."

BOOK REVIEWS

Books sent for review are acknowledged under: Books Received. This must be regarded as a sufficient return for the courtesy of the sender. Selections will be made for review in the interest of our readers as space permits.

Clinical Roentgenology of Pregnancy. By William Snow, M.D., Director of Radiology, Bronx Hospital; Roentgenologist-in-charge, Harlem Hospital, New York City. Cloth. Price, $4.50. Pp. 178, with 119 illustrations. Springfield, Illinois: Charles C Thomas, 1942.

The use of roentgen rays in pregnancy is not as prevalent as it should be. Almost every roentgenologist admits this and knows it is chiefly because he and his fellow specialists are negligent in giving such service as will create a demand for his assistance. The obstetrician has been skeptical, and rightly so, because information has been meagre and often inaccurate and misleading.

By writing this book, Dr. Snow has contributed much toward the rectification of these conditions. His work is the result of thorough painstaking study of methods used in many cases. Whereas most methods of pelvimetry have been too inaccurate or too complicated and theoretical, the method preferred by Dr. Snow and recommended by him is simple and sufficiently accurate for ordinary use. It is so clearly set forth that there is no excuse for anyone failing to comprehend or apply it.

In addition to presenting an excellent simple system of pelvimetry Dr. Snow's book contains much clinical material enabling the roentgenologist to quickly acquire an insight into the problems of pregnancy and to recognize and solve them intelligently. He does not stop with measurements of the maternal pelvis. His methods enable a reasonably accurate determination of height and weight of the fetus and the size of the fetal head, so that invaluable aid can be given in determining the important question of cesarean section. Dr. Snow believes that cases of mental inferiority and many ills of later life could be prevented by timely use of section instead of prolonged labor with undue crushing of the fetal head and excessive anoxemia.

One of the more important features of the work is a group of 22 case reports which show roentgenograms marked and outlined as in actual practice. They are reproduced to scale so that the student may make the actual measurements and work them out for himself if he so desires. Each of the representative cases contains a report chart with measurements, correction factor, true dimensions, and remarks. Data are given for the inlet, mid pelvis, and outlet, and include estimated age and weight of the fetus.

A well illustrated chapter on soft tissue demonstration contains some very interesting cases and should be inspirational to roentgenologists who have been doing less than their best to aid the clinician. The author's tables simplify the calculations greatly. No matter what method of pelvimetry the roentgenologist is accustomed to use, this work can hardly fail to broaden his scope and be of much practical value to him.

E. Walter Hall

Roentgen Treatment of Infections. By James F. Kelly, M.D., F.A.C.R., Professor and Director of the Department of Radiology, Creighton University School of Medicine; Attending Radiologist, Creighton Memorial St. Joseph's Hospital, St. Catherine's Hospital and Douglas County Hospital, Omaha, and Mercy Hospital, Council Bluffs, Iowa. With the Collaboration of D. Arnold Dowell, M.D., Assistant Professor of Radiology, Creighton University School of Medicine, etc. Cloth. Price, $6.00. Pp. 432, with 122 illustrations. Chicago: The Year Book Publishers, Inc., 1942.

Although this volume surveys the whole field of radiation therapy in infectious diseases, the largest section, comprising 130 pages, is devoted to an exhaustive review of the etiology, pathology and treatment of gas gangrene. Separate chapters deal with peritonitis, acute abdominal infections and pneumonia, and the other infections for which roentgen therapy is now accepted as a procedure of unquestioned value receive rather scant attention. A lengthy introduction includes a simplified discussion of roentgen-ray physics and the general considerations underlying radiation therapy, and the concluding chapter deals with contraindications.

Most radiologists will find it difficult to accept the author's conviction that any physician can safely undertake the roentgen treatment of infections without special training or experience.

Collected clinical reports from many sources are used to emphasize the value of irradiation, both as a prophylactic and a curative procedure in the treatment of gas gangrene. Unfortunately most of the reports include only a few cases and the group of patients studied personally by the authors seems hardly large enough to justify some of their sweeping statements. They confidently predict that the general adoption of their plan of roentgen therapy given early in the disease will reduce the mortality to 10 per cent and they insist that the wounded men in our armed forces should receive the benefit of their technique. Many of the unfavorable results are attributed to the presence of arteriosclerosis or diabetes and they feel that serum and the sulfonamides have relatively little to offer. Some of their poor results with irradiation are believed to be due to an antagonistic effect of sulfanilamide, and their enthusiasm is in no way dampened by persistently negative results obtained with roentgen treatment of animals infected with proved strains of *Clostridium welchii*.

This book represents a large amount of hard work in a new field and it should stimulate much confirmatory investigation in some of the large research centers.

Charles L. Martin

Physical Medicine: The Employment of Physical Agents for Diagnosis and Therapy. By Frank H. Krusen, M.D., F.A.C.P., Associate Professor of Physical Medicine, the Mayo Foundation, University of Minnesota; Head of the Section on Physical Therapy, the Mayo Clinic; Member of the Council on Physical Therapy of the American Medical Association, etc. Cloth. Price, $10.00. Pp. 846, with 351 illustrations. Philadelphia: W. B. Saunders Company, 1941.

The author could not have chosen a better title for his book because it indicates definitely that physical therapy is an integral part of Clinical Medicine and also that it includes, as shown in the subtitle, the employment of physical agents for both diagnosis and therapy. To appreciate its scope, its possibilities, one must not only read this book once but study its contents, which is made easy by the logical manner in which the subject matter is presented. As stated in the preface a uniform approach is used under the following headings: Introduction—definition—development—present status; physics; source, device or method of production; physiologic effects; technic of application; indications; contraindications, dangers and limitations; and conclusions. All phases of physical medicine are discussed: history of physical therapy; general application of heat; local application of heat; local and general applications of cold; light therapy; electrotherapy (the constant [galvanic or direct] current; static electricity; the faradic current; the interrupted galvanic and sinusoidal currents; diathermy); hydrotherapy; and mechanotherapy (massage, exercise, rest and relaxation and mechanical devices). There are additional chapters dealing with the clinical aspects of physical medicine, a brief discussion of physical therapy of arthritis, physical therapy in relation to orthopedic surgery, and the important and much debated subject of backache. The teaching of physical medicine to physicians, medical students and technicians is clearly outlined and the author's conclusions should be wholeheartedly endorsed. Problems regarding the hospital department of physical therapy are related in the last chapter and the Section on Physical Therapy at the Mayo Clinic is briefly described. A detailed bibliography accompanies each chapter and the index is excellent.

It is difficult to find any flaws or shortcomings in this book because such a wealth of accurate and valuable information has been assembled between its covers. It is recommended, therefore, not only as a textbook to medical students and practicing physicians but also as a valuable guide for daily reference to those specializing in physical therapy.

Ernst A. Pohle

The Treatment of Burns. By Henry N. Harkins, M.S., M.D., Ph.D., F.A.C.S., Associate Surgeon, Henry Ford Hospital, Detroit; Formerly Instructor in Surgery, University of Chicago; John Simon Guggenheim Memorial Fellow in Surgery, 1938–1939. Cloth. Price, $6.50. Pp. 457, with 120 illustrations. Springfield, Illinois: Charles C Thomas, 1942.

It has been widely acknowledged of late years that the treatment of burns is still unsat-

isfactory. Involving as they do problems of local wounds and general physiological abnormalities, they present in a concentrated form nearly all complications known to the surgeon. Clinical and laboratory studies have been carried on at an accelerated pace with the stimulus of the anticipation of mass occurrence of burns due to war action and civilian bombing.

Many controversial points still exist but this is an opportune time for summarizing the subject and making available the very considerable knowledge to most of us who have the time neither to cover the extensive literature nor to evaluate the new developments. The author is exceedingly well qualified to do this as he has made many important experimental studies on the subject, has had a wide clinical experience and an opportunity during his Fellowship to cover exhaustively the wide literature.

The book is presented in four parts, the burn and its effects, treatment, special burns including electrical and radiation burns, chemical burns and freezing and in Part IV a practical outline of burn treatment from which controversial points are omitted and definitive instructions are given for treatment of the burned patient in the home, by physicians and in the hospital. All phases of this injury including pathology, chemical changes, shock, fluid loss, infection, all recognized methods of treatment of all stages including plastic correction of scar are well and impartially presented. The illustrations are happily chosen, being informative and practical. Full page pictures with biographies of Dupuytren, Curling, Underhill and Davidson add historical atmosphere and interest. The book is perfectly documented with a bibliography of over thirteen hundred references. These include all papers on the subject up to the minute of publication. To make the bibliography accessible, there is appended to it a guide that directs reading by chapter, author and subject.

This is a most complete authoritative and up-to-date presentation of this important subject. Aside from the material on burns there is description of research that is important in other surgical problems, and discussions of surgical philosophy that will be valuable to all surgeons. The work is important from a historical standpoint as it presents a complete summary of the literature on the subject. To anyone interested in burns, in shock, in wound healing (all fundamentals of surgery) the book will be important. It is the only source for a complete bibliography, with a compilation and an impartial presentation of the controversial aspects concerning treatment now available. The practical and dogmatic advice concerning treatment makes its reading nearly obligatory to the family physician, the intern and resident, and its scholarly development of the entire theme will make it of interest to the most seasoned of surgeons. It is, in short, a finished picture of the subject, its history, literature, and unanswered problems, together with practical, usable advice about treatment of this dreadful form of trauma. The author and publisher are to be heartily commended for giving us this volume.

Frederick A. Coller

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ABSTRACTS OF ROENTGEN AND RADIUM LITERATURE

ROENTGEN DIAGNOSIS

HEAD

Hare, Hugh F. Roentgen changes in the cranial vault accompanying diseases resulting from metabolic disturbances. *Radiology*, June, 1941, *36*, 706–711.

The author calls attention to the fact that many diseases in which there are metabolic disturbances bring about changes in the bones which can be demonstrated by roentgen examination. Among such diseases are hyperparathyroidism, hyperthyroidism, non-tropical sprue, hypogonadism, menopausal osteoporosis, Cushing's syndrome, calcinosis universalis, osteomalacia, multiple myeloma, osteitis deformans, and metastatic malignancy. In all of these diseases there is osteoporosis and in some of them cystic changes in the bones, particularly of the vault of the skull. While the changes are not specific and a definite diagnosis of the disease cannot be made from the roentgenogram alone the roentgenologist may be able to suggest to the physician certain lines of clinical and laboratory investigation that will help to clear up the diagnosis. The study of calcium balance is particularly important. Roentgenograms are shown from cases of hyperparathyroidism, non-tropical sprue and hypogonadism.—*Audrey G. Morgan.*

Newell, R. R., and Borley, W. E. Roentgen measurement of visual acuity in cataractous eyes. *Radiology*, July, 1941, *37*, 54–61.

The authors discuss the physiology of roentgen-ray vision and describe their method of testing retinal function by means of roentgen rays. Eyes with different degrees of defective vision resulting from opacities of the media can be tested, regardless of the type or density of the opacity. Their experience in testing the eyes by this method in 61 cases before cataract operation is described. The results were such that they believe it will be possible to avoid most cases of poor vision after cataract operation by the use of this method and attention to vitamin A nutrition.

In the discussion Dr. Bruner said that he thought there were a good many practical clinical objections to this method. The time required for carrying it out seems to be out of proportion to the results obtained. The authors seem to have failed to take into account the fact that many patients with cataract have poor fixation. The test gives considerable information in regard to peripheral function but it is questionable whether it gives much in regard to macular function. The presence of central scotoma and retinal detachment can be determined just as easily by clinical methods. Central scotoma may be overlooked by any known method

and no matter how good the diagnosis many things can happen after the diagnosis is made, so that the skill of the surgeon and the cooperation of the patient are still the most important factors in giving good results.

In closing Dr. Newell said that the problem of fixation had not yet been settled. Roentgen-ray measurement of visual acuity is time consuming but that does not matter if it gives the patient something he cannot get in any other way. He believes Dr. Bruner misunderstood the purpose of the method which is to discover a scotoma or retinal detachment when opaque media make its discovery by clinical means impossible. If more can be discovered about the function of the retina before a cataract is removed it will be a great help to the patient. Even if it is impossible to guarantee reading vision after removal of a cataract it may be possible in some cases to tell the patient that it is impossible to restore reading vision by operation and give him the choice as to whether he wants operation under those circumstances.—*Audrey G. Morgan.*

WILLIAMS, E. ROHAN. On the radiological aspects of an investigation into the relationship of chronic irido-cyclitis, uveo-parotitis and tuberculosis. *Brit. J. Radiol.*, April, 1941, *14*, 116–127.

That certain chronic diseases of the eye are caused by tuberculosis has been proved by histological evidence. There is still considerable controversy as to the cause of others, including chronic irido-cyclitis and uveitis associated with parotitis. Tuberculous infection has been suspected to be the cause of these diseases also but many ophthalmologists have not been convinced of this.

As improvement in roentgen technique has made earlier and more accurate diagnosis of pulmonary tuberculosis possible, the author decided to make an investigation of this question. Roentgen examinations of the lungs were made in 40 cases of chronic irido-cyclitis from ophthalmological hospitals in London. There were positive findings in the lungs in 24 of these cases; there were old healed fibrotic or calcified pulmonary foci in 4 cases, active chronic pulmonary tuberculosis in 6, massive mediastinal and hilar lymph node enlargement in 2 and diffuse miliary and reticular pulmonary changes in 12. Among these 12 cases in which the roentgen findings suggested chronic miliary tuberculosis, tubercle bacilli or indisputable histological evidence of tuberculosis were found in 4. The parotitis and irido-cyclitis were only local manifestations of a generalized disease. The only other conditions with which the pictures could be confused were Schurmann's lymphangitis reticularis chronica and sarcoidosis and both of these are believed to be tuberculous in nature.

Six of the cases are described in detail and illustrated with roentgenograms.—*Audrey G. Morgan.*

NECK AND CHEST

JESSEL, G. The rôle of mass radiography in tuberculosis. *Brit. J. Radiol.*, June, 1941, *14*, 206–209.

Even with improved methods of roentgen examination the diagnosis of early tuberculosis is difficult because the amount of roentgen involvement does not run at all parallel with the severity or activity of the disease. The clinical facts must also be taken into consideration in judging of the activity of any given case.

Nevertheless mass roentgenography in the form of making photographs of the screen picture on miniature film and enlarging it has proved valuable both in industry and the army, chiefly in weeding out cases that require further roentgen and clinical examination. The fitness of a person for service should never be decided on the basis of the miniature film alone but should only mean that the man is to be sent for more complete examination and full-size roentgenograms made. This further examination and interpretation should be made by a team of radiologists and clinicians with experience in the diagnosis of tuberculosis.

Roentgenography in the diagnosis of tuberculosis has certain very definite limitations. A roentgenogram only shows the conditions present at the time of the examination. A negative finding does not guarantee that tuberculosis will not develop later. Therefore mass examinations must be repeated at intervals. Even if the findings indicate tuberculosis it does not necessarily mean that the disease is active. The roentgen findings may be consistent with other diseases as well as tuberculosis.

Mass examinations should not be associated in the public mind with tuberculosis because of the psychological effect. They should be considered a part of a general health survey and should not be made at a tuberculosis dispensary. Definite standards of technique and interpretation must be adopted if comparable results are to be attained.—*Audrey G. Morgan.*

Paul, L. W., and Pohle, E. A. Mediastinal and pulmonary changes in erythema nodosum. *Radiology*, Aug., 1941, *37*, 131–137.

Little attention seems to have been paid to roentgen examination of the lungs in erythema nodosum. It has been quite generally assumed that this disease is a specific infection of unknown origin or is due to rheumatic fever or streptococcus infection.

The authors have made roentgen examinations of the chest in 20 cases of erythema nodosum. Histories and roentgenograms of a number of the cases are given. All but one of the patients were adults. In 8 cases there were no roentgen signs of previous or present disease of the chest. In 3 there were slight signs probably not related to the erythema nodosum. In 3 there were slight but definite signs of disease of the lymph glands at the hilum and in 6 very marked enlargement of these glands. In 2 of the cases it was definitely proved that the enlargement of the glands was caused by tuberculosis and in 4 others tuberculosis was believed to be the cause of the gland disease and the erythema nodosum.

The authors believe that in all cases of erythema nodosum roentgen examination of the chest should be made as in enlarged hilum glands both the gland enlargement and the erythema nodosum are apt to be caused by tuberculosis. Even if the first examination is negative follow-up examinations should be made before the patient is discharged as free of tuberculosis. They do not claim that all cases of erythema nodosum in adults are caused by tuberculosis but they want to emphasize the fact that not all of them are caused by rheumatic fever or streptococcus infection and to stress the importance of roentgen examination of the chest.—*Audrey G. Morgan.*

Nessa, Curtis B., and Rigler, Leo G. The roentgenological manifestations of pulmonary edema. *Radiology*, July, 1941, *37*, 35–46.

Little has been written about the roentgen findings in pulmonary edema. As the condition is acute it is often not thought advisable to take the seriously ill patient to the roentgen room.

The authors discuss 110 cases of pulmonary edema that came to necropsy. In 18 of these roentgen examinations had been made before death. Seven of the cases are described in detail and illustrated with roentgenograms in order to show the different pictures presented. The classical type with bilateral, symmetrical, homogeneous widespread density does not occur in the majority of cases. The fluid tends to collect in the center of the lungs, leaving the periphery clear. This results in a butterfly-shaped density. In 1 of the cases described the fluid collected first in groups of alveoli which later became confluent, giving stippled, irregular but widespread densities. Pulmonary edema may be localized to one lobe or one lung and so simulate pulmonary edema or infarct. No satisfactory explanation can be given for this localization. It cannot always be diagnosed when the picture is atypical but it should be considered in cases of heart failure, kidney disease, liver disease, after operations and following transfusion reactions. One notable cause of pulmonary edema is the administration of excessive amounts of fluid after operation. Though the author chose cases which came to autopsy for the purposes of his paper many patients recover from pulmonary edema following operation.—*Audrey G. Morgan.*

Berg, Gunnar, and Zachrisson, C. G. Cystic-lungs of rare origin—tuberous sclerosis. *Acta radiol.*, 1941, *22*, 425–436.

Three cases of cystic lungs from tuberous sclerosis are described. Two of the patients were sisters and in the elder the disease proved fatal. The disease is known to be familial. The roentgenogram shows a honeycomb-like appearance of the lungs due to the presence of many cysts with septa of varying thickness between them. In the case which was autopsied there were tumors in the brain and kidneys of the same nature as those that have been described previously in tuberous sclerosis.

The differential diagnosis of this condition is discussed and roentgenograms given showing the appearance in this form of cystic lung, cystic lung in diabetes insipidus, acute and chronic miliary tuberculosis, benign lymphogranuloma, silicosis and lymphangitis carcinomatosa reticularis.—*Audrey G. Morgan.*

Westermark, Nils. A roentgenological investigation into traumatic lung changes arisen through blunt violence to the thorax. *Acta radiol.*, 1941, *22*, 331–346.

Traumatic lesions of the lungs from blunt violence to the thorax may be brought about by laceration of the tissues by fragments of fractured bones. But they may also occur when

there has been no fracture. Sudden compression of the lung may cause rupture of the bronchi and vessels followed by the secondary appearance of interstitial emphysema and hemorrhage. If infection of hemorrhagic infiltrations occurs it may cause severe disease, such as acute or chronic bronchitis, bronchiectasis, pneumonia, gangrene of the lung, pleurisy or empyema.

The author reports 124 cases of blunt injury of the thorax in which roentgen examination was made immediately after the accident. There were changes in the lungs in 94 of these, or 75.8 per cent. Among the cases in which there was fracture there were changes in the lungs in 86.7 per cent (52 out of 60 cases) and among those in which there was no fracture there were lung changes in 65.6 per cent (42 out of 64). As the violence was doubtless greater in the fracture cases it would seem that roentgenographic lung changes increase with increased degrees of violence.

The lung changes cleared up after two to three weeks in 53.2 per cent of the cases. In these cases they were slight and caused no symptoms. In 46.8 per cent (44 out of 94) there were more or less severe complications, such as empyema, pneumonia and bronchitis. These generally came on four to fourteen days after the accident.

As there are usually no symptoms in these cases unless complications develop, it is well to have a roentgenogram made early. From the medicolegal point of view lung diseases are not acknowledged to be of traumatic origin unless symptoms appear within three to four days after the accident. Judging from the author's material post-traumatic pneumonia may occur later than this. Early roentgenograms may be of value in proving the traumatic origin of the disease in such cases.—*Audrey G. Morgan.*

BALL, ROBERT P., and CRUMP, ARMISTEAD C. Mega-esophagus (cardiospasm); report of a case with subdiaphragmatic herniation of the esophagus. *Radiology*, May, 1941, *36*, 575–582.

A case is reported in a student nineteen years of age who had just graduated from high school and had suffered emotional shock in the death of a grandmother of whom he was very fond. He began to have difficulty in swallowing and a feeling of pressure beneath the sternum which grew steadily worse. Finally he was obliged to empty the esophagus before going to bed by lowering his head and spasmodically contracting the abdominal muscles. It was over a year before he consulted a physician.

Roentgen examination showed the esophagus dilated with a considerable amount of food residue. The dilated part of the esophagus passed through the hiatus in the diaphragm and reached to about 12 cm. below it, ending in a dilated pouch. At intervals deep contractions occurred, sometimes several at a time, giving the esophagus a writhing, twisting movement. No barium passed out of the distal end until the patient forced it out.

Treatment by lavage was unsuccessful and the dependent part of the esophagus was anastomosed with the pars media of the stomach near the lesser curvature. Re-examination some six months later showed the esophagus smaller, its length had decreased and the stoma was near the level of the hiatus. The patient could eat anything he wished without difficulty.—*Audrey G. Morgan.*

CHRISTIANSEN, HARALD. Brachyesophagus with dystopic cardia. *Acta radiol.*, 1941, *22*, 360–366.

There are cases in which the esophagus is congenitally short and the cardia displaced upward into the thorax. Up to 1931 very few cases had been reported but in that year Findlay and Kelly published a case of stricture of the esophagus in the thorax with gastric mucosa immediately below it continuing down into the stomach. These cases are apt to be confused with ones of diaphragmatic hernia and roentgen examination is important in the differentiation.

The author describes 4 cases, 2 in infants and the other 2 in elderly adults. The 2 latter patients died and autopsy confirmed the roentgen diagnosis. Roentgen examination showed a constriction of the esophagus at the 6th to 8th vertebra with gastric mucosa passing down from it.

The abnormality does not necessarily cause symptoms but constriction of the cardia may cause spasm and vomiting as in the author's first case, or it may cause hematemesis as in the second case in which the stomach was incarcerated in the muscular part of the diaphragm. In the third case, in a woman of fifty-three, there was a carcinoma of the cardia but it is not known whether there was any connection between it and the malformation. In the fourth case there was inflammation of the cardia which finally led to complete stenosis.

The treatment is symptomatic, particularly dilatation of the stenosis.—*Audrey G. Morgan.*

Grishman, A., Steinberg, M. F., and Sussman, M. L. Tetralogy of Fallot: contrast visualization of heart and great vessels. *Radiology*, Aug., 1941, *37*, 178–180.

Since Robb and Steinberg first published their work on contrast visualization of the heart chambers in 1938 it has been found useful in the study of congenital heart disease. The authors report a case in which the pathological physiology of tetralogy of Fallot was established by this method. They have not found any similar report in the American literature. Roentgenograms and drawings made in the left anterior oblique position are given.

The patient was an Italian man of twenty-six who has had cyanosis and clubbed fingers since birth. He was fairly active until March, 1938, when he was admitted to the hospital complaining of pain in the right lower chest and dyspnea. A contrast visualization by the original method of Robb and Steinberg was not conclusive. In May, 1940, the examination was repeated using both the moving picture and the multiple exposure techniques with diodrast. These showed hypertrophy and dilatation of the right ventricle, stenosis of the pulmonary artery above the conus, a defect in the intraventricular septum with right to left shunt and dextroposition of the aorta. The left ventricle was very small and remained visible long after the other parts of the heart and great vessels. Evidently there was no outlet from the left ventricle except through the defect in the septum.

The fluorographic multiple exposure technique or the cineroentgenographic method is necessary in such cases as that is the only way in which a sufficient number of exposures can be made in a short time.—*Audrey G. Morgan.*

Beck, Claude S. Compression of the heart. *Radiology*, July, 1941, *37*, 47–53.

Chronic compression of the heart, which is the condition considered in this article, is generally caused by pericardial scars, though it may be caused by blood, pus, transudate or exudate in the pericardial cavity or mediastinum, tumors of the heart or pericardium or strangulation of the heart through a rent in the pericardium. It differs from acute compression in the fact that venous pressure can rise much higher. The unmistakable symptoms are ascites, high venous pressure, quiet, small heart, and enlargement of the liver. In many cases there are calcifications in the pericardium. Contrary to quite generally accepted opinion adhesions with traction in the long axis of the heart do not cause extrinsic heart disease.

No medical treatment is of any avail in chronic compression of the heart but the condition can be relieved almost as if by magic by surgical operation on the scars that cause it. The ascites disappears, circulation becomes normal and the subject is changed from a chronic heart patient to a normal, healthy person. The cure is permanent and there is little risk in the operation if it is performed with due surgical skill.

Photographs are given of patients before and after operation.—*Audrey G. Morgan.*

Vieta, John O., and Craver, Lloyd F. Intrathoracic manifestations of the lymphomatoid diseases. *Radiology*, Aug., 1941, *37*, 138–159.

The authors report the roentgen examination of 794 cases of lymphomatoid disease with postmortem examination in 160 cases. These showed a high percentage of lesions in the chest and they believe that if more frequent roentgen examinations of the chest were made the percentage would be even higher than in this series. Often these intrathoracic lesions are silent clinically and roentgen examination furnishes the only means of arriving at knowledge that will make it possible to treat the deep-seated lesions of these diseases.

In the roentgen examination of 335 cases of Hodgkin's disease there were intrathoracic lesions in 74 per cent, and postmortem examination showed lesions in 88 per cent. Among 239 cases of lymphosarcoma roentgen examination showed intrathoracic involvement in 54 per cent and autopsy in 73 per cent, less than in Hodgkin's disease. In 158 cases of lymphatic leukemia the chest was found involved in 72 per cent on roentgen examination and the mediastinal or hilar nodes were involved in 83 per cent of the 31 cases examined postmortem. In 52 cases of myelogenous leukemia 82 per cent showed no intrathoracic lesions on roentgen examination and among the 23 cases autopsied 52 per cent were free of chest lesions. There was myeloidization of enlarged mediastinal or hilar nodes in 47 per cent. In 10 cases of mycosis fungoides mediastinal or hilar nodes were found in 10 per cent and parenchymal infiltration in 30 per cent. No autopsy material was available

in this disease. Tables are given showing details in regard to the nature and distribution of the lesions in the various diseases.

Attention is called to the fact that patients with lymphomatoid disease may also have other types of tumor. Among the authors' 160 autopsied cases there were 4 with malignant tumors of the gastrointestinal tract.—*Audrey G. Morgan.*

GOSSE, A. HOPE. A right-sided aorta. *Brit. J. Radiol.*, June, 1941, *14*, 215–216.

Aorta on the right side is extremely rare. A case in a man of fifty-six is described which is particularly interesting from the fact that it had never caused any disturbance of any kind. The patient was sent to the author with a diagnosis of malignant mediastinal tumor based on a homogeneous shadow to the right of the sternum in the upper mediastinum. The author's examination showed that the symptoms were caused by a resolving dry pleurisy. He had taken a roentgenogram of the patient in 1936 and comparison showed that the shadow on the right side had not changed in four years, showing that it could not be due to malignant glands in the mediastinum. He believed it was due to a right-sided aorta and this diagnosis was confirmed by a specialist. Two roentgenograms of the case are given and an electrocardiogram made in 1936 which showed only the preponderance of the left ventricle so common in middle life and later, and no abnormalities.—*Audrey G. Morgan.*

EDLING, NILS P. G. Aneurysm of an intercostal artery with simultaneous, sarcomatous destruction of an adjacent, dorsal vertebra. *Acta radiol.*, 1941, *22*, 411–421.

A case is described in a man of forty-six who had been well until about a year before admission to the hospital when he began to suffer from digestive disturbance and dull abdominal pain under the right costal arch radiating to the back and up under the right shoulder. Roentgen examination showed a round dense area the size of an infant's head in the lower part of the right lung field, adjoining the heart shadow. It could not be projected free from the spinal column but was separated from the diaphragm, the mobility of which was normal. No details could be seen in the opaque area. Its center was on a level with the 9th dorsal vertebra which showed a rarefaction the size of a hazelnut on the right side. From the roentgenograms a diagnosis was made of primary tumor in the right lung with metastasis in the 9th dorsal vertebra, or of a neurinoma growing from the spinal canal. The latter diagnosis was considered rather the more probable.

The patient's condition grew rapidly worse and it was impossible to make further roentgen examination. He died eight weeks after admission.

Autopsy showed an osteolytic sarcoma which was apparently primary in the 9th thoracic vertebra. It also showed an aneurysm of an intercostal artery filled with thrombotic masses. The aneurysm was apparently much older than the sarcoma which had evidently had a very rapid destructive action and yet had not spread beyond the one vertebra. There was no evidence of an etiological relationship between the two processes and the only theory that would satistorily account for both of them would be that of trauma. There was no history of either trauma or previous disease but as the patient was a lumberman he may conceivably have suffered some injury which damaged the intercostal artery and caused the aneurysm and, after a latent period, the osteogenic sarcoma.

The case shows the difficulty of interpreting rounded shadows in the thorax.—*Audrey G. Morgan.*

RIGOS, FRANK J. A roentgenographic study of pleural effusion. *Radiology*, May, 1941, *36*, 568–574.

Between 1919 and 1938, 5,731 patients were admitted to the Glen Lake Sanatorium; of these 233 had pleural effusions. The age and sex distribution of the effusion cases was practically the same as that of the general admissions for tuberculosis. The figures for effusion as compared with those for tuberculosis by stages show that pleural effusions form more frequently cases of minimal and moderately advanced tuberculosis than in far advanced cass. Roentgenograms showed that 172 of the patients had typical effusion and 41 massive effusion. These two groups constituted 97 per cent of the whole number of cases. The other 3 per cent were atypical. In the upright roentgenogram effusions of less than 400 cc. cannot be detected. In about 75 per cent of the cases the associated tuberculosis was of the nodular or fibrotic type. The type of tuberculosis could be diagnosed from the roentgenogram in 197 of the cases. In the remaining 36 the pulmonary lesion was hidden by the effusion. There were cavities on

the same side as the effusion in 34 cases, on both sides in 20 and on the opposite side in 12 cases.

Later studies were made on 190 cases. It was found that prognosis was somewhat better in cases that had a small amount of effusion. The resolution of the effusion was not dependent on cure of the associated tuberculosis. Among the 72 cases in which roentgenograms were available 31 showed complete resolution and 41 incomplete. The complete resolution had occurred in 19 of the cases (60 per cent) within two years. The most frequent finding in the cases with incomplete resolution was obliteration of the costophrenic angle by adhesions. Cases in which there was a large amount of fluid and in which aspiration was performed did not show as complete resolution as those in which there was less fluid and aspiration was not done. The commonest and most persistent roentgen finding was obliteration of the costophrenic angle.—*Audrey G. Morgan.*

ABDOMEN

FELDMAN, MAURICE. A new roentgen sign of pyloric obstruction: the roentgen visualization of the stomach without the use of contrast media. *Radiology*, June, 1941, *36*, 736–738.

If a homogeneous image of the whole stomach can be seen without contrast medium in a fasting patient it indicates gastric retention caused by obstruction of the pylorus. This is a new roentgen sign of pyloric obstruction and is caused by the excessive amount of fluid retained in the stomach. This shadow may resemble that of a tumor of the stomach, an aortic aneurysm, a tumor or cyst of the kidney, a subdiaphragmatic abscess or a diaphragmatic tumor, an enlarged spleen, an adrenal tumor, a cyst of the pancreas, or an enlargement of the left lobe of the liver.—*Audrey G. Morgan.*

CRAIG, W. JOHNSTON. Primary carcinoma of the jejunum: a case report. *Brit. J. Radiol.*, June, 1941, *14*, 210–212.

A case is described in a woman of forty-eight, who for some months had complained of pain which had lately become colicky in type. She had vomited occasionally and had lost some weight. Roentgen examination showed nothing abnormal in the stomach or jejunum. Therefore a careful examination was made of the jejunum which showed a stricture at 3 to 4 inches beyond the duodenojejunal junction with dilatation above it. A diagnosis of malignant lesion of the jejunum was made and operation performed a week later. During this interval the vomiting had become more frequent. A tumor was found at the site indicated in the roentgenogram and histological examination showed it to be a papillary alveolar and tubular columnar cell carcinoma of the jejunum. Two roentgenograms and a photograph of the specimen are given. The patient made an uneventful recovery. The prognosis is bad in these cases. Rankin of the Mayo Clinic says that the average duration of life after operation is one year.

The importance of making a careful examination of the small intestine and not being content with normal findings in stomach and duodenum is emphasized.—*Audrey G. Morgan.*

MCMULLEN, J. W. A roentgenographic study of the relative incidence of gastric and duodenal ulcer. *Radiology*, Aug., 1941, *37*, 194–196.

It was formerly thought that gastric ulcer is more common than duodenal ulcer but recent statistics have tended to reverse this proportion. The author made a study based on 4,400 consecutive gastrointestinal examinations from 1926 to 1939 at the Colorado General Hospital. A total of 883 gastric and duodenal ulcers was seen—that is, an incidence of slightly more than 20 per cent of the whole number of cases examined. Of these 689, or 78 per cent, were duodenal, and 194, or 22 per cent, were gastric. The figures in the literature show a wide variation from these percentages.

A curve is given showing the incidence of gastric and duodenal ulcer in men and women for the different decades of life based on these cases. The relative incidence of duodenal and gastric ulcers is 3:1 for women and 4:1 for men. The peaks of incidence of gastric and duodenal ulcer in women were found in the fifth and fourth decades respectively while in men they were in the sixth and fifth decades respectively.—*Audrey G. Morgan.*

REES-JONES, G. F. Diaphragmatic movement after lower abdominal operations. *Brit. J. Radiol.*, July, 1941, *14*, 247.

A table is given showing the results of screen examination to determine the excursion of the diaphragm after herniotomy and appendectomy. Screen examinations were made six, twenty-four, forty-eight and seventy-two hours

after operation. It was found that on quiet respiration there was very little movement of the diaphragm for twenty-four hours after operation. The diaphragm was more fixed and remained fixed longer on the side of the operation than on the opposite side. It was more fixed after fascial repair for inguinal hernia than after appendectomy. The diaphragmatic movements frequently returned to normal after forty-eight hours and almost always after seventy-two hours. The examinations show that a fixed diaphragm on the side of the operation for forty-eight to seventy-two hours has no pathological significance. Complications developed in only 1 of the 30 cases examined here. This was an atelectasis of the left lower lobe and examination before operation had shown a fixed diaphragm on the opposite side.—*Audrey G. Morgan.*

BEILIN, D. S. Diaphragmatic hernia of the stomach. *Radiology*, July, 1941, *37*, 68–74.

The author discusses the anatomy and embryology of diaphragmatic hernia and reviews 26 cases of his own. Among these patients 1 also had carcinoma of the stomach, 3 had duodenal ulcer, 1 diverticulitis of the esophagus, 1 diverticulum of the cardiac portion of the stomach and 1 gallbladder disease with gallstones.

The symptoms of diaphragmatic hernia of the stomach may be respiratory or gastrointestinal or a combination of the two. In many cases they are so varied and uncharacteristic that they have little value. The chief means of diagnosis is by roentgen examination.

If the symptoms are mild medical treatment may be sufficient. Patients often go through life without any very great disturbance from such a hernia. But if the symptoms are severe enough to warrant it operation should be performed, the herniated viscera replaced in the abdomen and the abnormal opening in the diaphragm repaired.

Among the author's cases 8 were operated on and 18 treated symptomatically. Of the 8 patients operated on 7 recovered uneventfully and 1 died. One had a moderate recurrence of the hernia six months later. In the 1 case that was autopsied the whole stomach and left splenic flexure were in the left half of the chest. The tendinous part of the left diaphragm was defective with a rent 10 cm. long. The patient died from shock.

Spot roentgenograms should be taken of all diaphragmatic hernias that are of clinical significance.—*Audrey G. Morgan.*

POPPEL, M. H., and LEVY, A. H. Pancreatic lithiasis. *Radiology*, Aug., 1941, *37*, 174–177.

Three cases of lithiasis of the pancreas are described and illustrated with roentgenograms. Roentgen examination is the only certain method of diagnosing this condition which was only rarely diagnosed during life before the introduction of roentgenography.

These calculi are generally composed of calcium carbonate and phosphate. They result from pancreatitis and alcoholism is a prominent factor in their production. Pain resembling that of gallbladder colic is a frequent symptom. Roentgen examination generally shows multiple dense calculi along the course of Wirsung's duct.—*Audrey G. Morgan.*

BROWN, SAMUEL, MCCARTHY, J. E., and FINE, ARCHIE. Pancreatic tumors; a roentgenologic study. *Radiology*, May, 1941, *36*, 596–603.

Roentgen diagnosis of tumor of the pancreas is difficult because the shadows of several organs are superimposed in this region. It can be made indirectly, however, from a study of changes in the position and outline of the stomach and duodenum caused by pressure from the tumor. Twelve cases of tumors of the pancreas and other organs in the region, particularly the common duct, are described and illustrated by roentgenograms, attention being called to the differential signs between tumors of the pancreas and other tumors. Needless to say a thorough knowledge of the normal anatomical relations is a necessity in this diagnosis.

In the discussion the value of the lateral view in this diagnosis was brought out. With this view it is possible to differentiate between lesions of the pancreas posteriorly and lesions of the liver anteriorly. In early enlargements of the head of the pancreas there is an inverted-three filling defect on the medial side of the descending portion of the duodenum. In the prone lateral view a tumor of the pancreas may project forward into the gas-filled stomach and be clearly visible. The stomach is often displaced upward in the recumbent position, especially in obese patients. In such cases the patient should be examined standing also.—*Audrey G. Morgan.*

LEVITIN, JOSEPH. Intraperitoneal localized abscess: roentgenologic aid in diagnosis. *Radiology*, Aug., 1941, *37*, 205–207.

It is sometimes hard to diagnose a localized intraperitoneal abscess, especially after surgical

operation when there are several possibilities. The author discusses two roentgen findings which are of value in such a diagnosis. The first is an ileus, which is not a true paralytic ileus but an inhibition of the action of the bowel due to over-stimulation of the sympathetic by the inflammation. The other is the absence of the normal properitoneal fat line, or the dark stripe caused by the properitoneal fat, which is seen on ordinary roentgenograms. Four illustrative cases are described.

These signs may occasionally be absent, as in a case of ruptured appendix recently seen with quite a severe localized abscess. The mass was buried in the false pelvis beneath the omentum and the area was covered by a dense congenital band which was adherent to the brim of the pelvis and extended over the bladder. The abscess was so isolated from the peritoneum that there was no stimulation of the peritoneum sufficient to cause an ileus. The position of the abscess was such as to prevent infiltration of the properitoneal fat by fluid and therefore the properitoneal fat line was present. But ordinarily these two symptoms furnish a means of diagnosis.—*Audrey G. Morgan.*

Holmgren, Bengt S. Zwei interessante Fälle Sigmoideumvolvulus. (Two interesting cases of volvulus of the sigmoid.) *Acta radiol.*, 1941, *22*, 404–410.

The surest way of diagnosing a volvulus of the sigmoid is by roentgen examination. Two cases are described. The first was in a man of eighty who for nine months had had stubborn constipation. After some days of constipation the abdomen distended but collapsed after a stool or enema. The last time he had not been able to relieve the constipation by enema and came to the hospital after five days of absolute constipation.

Roentgen examination showed torsion of at least 360° in a loop of sigmoid. The picture differed from the usual one of volvulus of the sigmoid in the fact that both the ascending and descending colon showed fluid levels and that the cecum and a part of the ascending colon were larger than the twisted sigmoid loop. The picture suggested a deep stenosis of the colon due to cancer rather than volvulus of the sigmoid. The abdomen was opened and a tube passed through the rectum and guided by the hand into the volvulus. Large amounts of gas and fluid were passed and the torsion reduced. The patient was in very bad general condition, however, and died after twelve hours without having regained consciousness.

Another case is described in which the volvulus was reduced without operation by introducing a stomach tube into the rectum and passing it, under screen observation into the volvulus, on which gas and diarrheal intestinal contents was passed and the volvulus was reduced spontaneously. The torsion in this case was loose, while in the previous case it had persisted for five days and was very tightly twisted.—*Audrey G. Morgan.*

Lewis, R. I. A case of lympho-granuloma inguinale producing rectal stricture. *Brit. J. Radiol.*, Sept., 1941, *14*, 298–299.

Lymphogranuloma inguinale is very rare in England. A case is described in a woman of forty-four who complained of colicky abdominal pain, flatulence, constipation and vomiting and recently a feeling of incomplete evacuation of the rectum. She had lived in Malta and South Africa up to the age of twelve. Her husband had never been abroad. There was a discharging sinus near the anus and the skin around the anus was suppurated. The inguinal glands were enlarged. Barium enema examination showed a marked stricture of the rectum which was so long that it argued against a diagnosis of carcinoma of the rectum. An excised piece of tissue showed chronic inflammation. A Frei test was made and proved positive. The Wassermann reaction was negative. A diagnosis of lymphgranuloma inguinale was made.—*Audrey G. Morgan.*

Renander, Axel. Roentgenologic features of tuberculosis of the rectum. *Acta radiol.*, 1941, *22*, 367–370.

A case of tuberculosis of the rectum in a woman of forty-three is described. She had had violent straining at stool for several weeks. The stools were mixed with much mucus and some blood. There was no pain. She had lost some weight. Roentgen examination showed annular infiltration of the rectum for a distance of about 10 cm. with nodules in the mucous membrane. In spite of this extensive infiltration, however, the rectum showed good power of contraction. This proved that the muscularis propria was functioning and that therefore the infiltration, though extensive, was not deep. This is a valuable point in differentiating between tuberculosis and cancer or syphilis of the rectum.

No focus was found in the lungs or elsewhere so this was apparently a case of primary tuberculosis of the rectum, which is rare.—*Audrey G. Morgan.*

GENITOURINARY SYSTEM

RIDLON, G. R. Atypical pyelograms in cystic disease of the kidney. *J. Urol.*, Sept., 1941, *46*, 480–485.

The author presents 3 cases of cystic disease of the kidney, each of which had atypical pyelograms. The first case was that of a male aged fifty-one, who complained of pain and a mass in the left loin. Red blood cells were present in the urine. The pyelogram showed a cavity filled with medium in the upper pole of the left kidney and from this film a diagnosis of a degenerating carcinoma was made. Operation disclosed a cyst in the upper pole of the kidney which communicated with the renal pelvis through a small sinus. After evacuation of the cyst a pyelogram seventeen months later showed a normal pelvis.

The second case was that of a thirty-three year old white male who complained of irregularly recurring episodes of "smoky urine" for one year and frank hematuria for two days. A pyelogram showed a large collection of contrast medium in the upper pole of the right kidney and a diagnosis of hemorrhagic cyst was made. At operation a polycystic kidney was found containing hemorrhagic cysts.

The third case was that of a fifty-eight year old white woman who had no kidney complaints. A routine urogram showed a lesion suggesting a solitary cyst of the right kidney. The author made a diagnosis of hydrops of the gallbladder of the pyelogram. Operation disclosed a solitary cyst of the kidney.—*R. M. Harvey.*

WILLIAMS, E. ROHAN. Pyelo-renal backflow. *Brit. J. Radiol.*, Sept., 1941, *14*, 275–283.

In studying retrograde pyelograms roentgenologists sometimes see a backflow of the opaque medium. The backflow may be pyelovenous, pyelolymphatic, pyelotubular or pyelointerstitial (extravasation). Experimental work had been done on this pyelorenal backflow before the roentgen era but it was of only academic interest. With the introduction of pyelography, however, it became important clinically. In 1924 Hinman and Lee-Brown in studying the vascular anatomy of the kidney on celloidin-corrosion preparations proved that venous backflow resulted from multiple ruptures from the fornix calycis directly into the veins around the calyces. The anatomy of the venous and lymphatic drainage system of the kidney is discussed and a composite diagram given to illustrate the venous drainage of the kidney and the pyelographic appearances of the various forms of backflow. Pyelograms of illustrative cases are also given.

Experimental work on the subject is discussed. The only form of backflow that can occur without rupture of the calyces is the pyelotubular form. The venous and interstitial forms may be caused by injury of the walls of the calyces by the tip of the catheter, or even the force of the jet from the catheter tip during injection may cause rupture of the fornices. Even a slight degree of overfilling may be followed by venous backflow or minor degrees of extravasation. But even when the technique of pyelography is perfect pyelotubular and pyelolymphatic backflow may be seen. Tubular backflow is of no importance if a non-toxic substance is used for the contrast medium; lymphatic backflow suggests that there is some abnormal communication, congenital or acquired, between the lymphatic channels and the pelvis and calyces.—*Audrey G. Morgan.*

NOWELL, STANLEY. Increasing density of the renal shadow during excretion urography; a sign of acute ureteric obstruction. *Brit. J. Radiol.*, April, 1941, *14*, 138–143.

Three cases are reported which, in excretion urography showed increasing density of the kidney shadow during the examination. In 2 of them the calyces and pelvis could not be seen while in the third they were enlarged. In all the cases there was a stone in the ureter on the side of the increased density. Evidently the increasing density is caused by the contrast medium being concentrated in the kidney tubules as a result of pressure resulting from the damming up of the urine in the kidney pelvis. This finding therefore indicates that the kidney is functioning and in cases in which the kidney is suspected of not functioning it should be looked for. If present it proves kidney function. If there is known to be a stone in the ureter the increasing density indicates that the condition is in the acute phase. It may be the means of demonstrating the presence of a non-opaque stone in the ureter. In acute cases with abdominal pain on the right side, suggesting appendicitis it may be the means of making a differential diagnosis

and determining that the pain is caused by obstruction of the ureter.—*Audrey G. Morgan.*

Wyatt, George M. Excretory urography for children. *Radiology*, June, 1941, *36*, 664–671.

Disease of the urinary tract is not uncommon in children and is responsible for a considerable number of deaths. Pyelography is necessary for the early diagnosis of these conditions and descending urography is safer and less complicated and more physiological than the retrograde method. Directions are given for carrying out excretory urography in small children. Gas in the small intestine is the greatest obstacle to satisfactory urography up to the age of six or eight years and should be avoided by keeping the patient in the upright or prone position or on the right side. The supine position and that on the left side should be avoided. Fluids should not be too greatly restricted as it makes the children too uncomfortable and they cry, thus increasing the gas. Lack of concentration of the urine is best compensated for by increasing the amount of contrast material. Diodrast has been used as a contrast medium in more than one thousand cases at the Children's Hospital in Boston without any bad effects, though fatalities from its use have been reported in the literature. Dose for children under six months of age 10 cc., six months to two years 15 cc., two to five years 20 cc. and over five years 25 cc. If the child is too young to stand, one person should hold his shoulders and another his upper thighs to prevent the twisting motions characteristic of young infants.

The average technique for an infant six months of age calls for 65 kv., 200 ma., 1/20 sec., 36 inches target-film distance, Lysholm grid. Speed is so important that if a sufficiently short exposure cannot be made at the usual target-film distance it is better to decrease the distance than to increase the exposure time. First films are taken with the patient upright to avoid gas in the small intestine and later ones in the recumbent position to get optimum concentration of the dye. Films are usually taken five, fifteen and thirty minutes after injection of the dye in order to establish a standard for the comparison of cases.—*Audrey G. Morgan.*

Bowen, J. Andrew, and Shiflett, E. Lee. Intravenous urography in the upright position. *Radiology*, June, 1941, *36*, 672–677.

The authors carried out intravenous urography in the upright position on 19 persons, 12 females and 7 males. No preparation was given. The contrast medium was diodrast, 30 cc. A preliminary five minute film was made in the supine position, then films were made in the upright position after twenty, thirty-five and fifty minutes, then a final one in the supine position. Seven of the 19 persons, or 36.8 per cent, were found to have gross anomalies. One man had a bilateral hydronephrosis, 2 women bilateral ptosis and 4 women unilateral ptosis. The minimal descent considered ptosis was 5 cm. and the maximal 9 cm. In the cases with bilateral ptosis there was dilatation of the pelves. They believe these women with ptosis will be more liable to infection in later life, particularly in connection with child-bearing and that they will show a greater tendency to stone formation than women with their kidneys in normal position.

The calyces, pelves and ureters were not so well defined as in the prone position which the authors believe is due to increased peristalsis in the upright position. They conclude that kidney abnormalities are more common than is generally believed. They do not think that abnormal roentgen signs without clinical findings should be considered an indication for surgery.

In the discussion it seemed to be the opinion that these cases of ptosis are not of special importance and that the reason for the poorer visualization of the urinary tract was simply gravity rather than increased excretion. *Audrey G. Morgan.*

Thomas, Gilbert J., Stebbins, T. L., and Sandell, Samuel T. Roentgenology of renal tuberculosis. *Radiology*, June, 1941, *36*, 678–683.

The authors have examined 7,700 patients from a private clinic in a large metropolitan area and a 700-bed county sanatorium which admits patients with all types of tuberculosis. Among 4,199 patients from this group whose records were complete 4.1 per cent had tuberculosis of one or both kidneys. The plain roentgenogram of the kidney is of little value in the diagnosis of early tuberculosis. It is useful in about 25 per cent of advanced cases. Even excretory urography is not decisive in the diagnosis of early tuberculosis; if it is negative retrograde pyelography must be performed in order to exclude the disease definitely.

If a patient has bone tuberculosis careful

examination should be made for tuberculosis of the kidney. Associated tuberculosis of the bones and joints and of the kidney is the most frequent combination of lesions resulting from the hematogenous spread of the disease from the lungs. Not only is urographic examination of value in the diagnosis of kidney tuberculosis but the progress of the disease and the effect of treatment can be followed up by means of serial pyelograms. If sinuses remain after the surgical removal of a kidney their course can be shown by a roentgenogram taken after the injection of an opaque suspension into them.

In the discussion Dr. Kornblum emphasized the importance of the urologist and roentgenologist appreciating the limitations of excretory urography. When a kidney tuberculosis can be diagnosed by descending pyelography it is no longer early. Roentgenologists particularly should pay more attention to this subject and should make a more thorough study of urology. —*Audrey G. Morgan.*

RENANDER, AXEL. Another case of spontaneous rupture of the renal pelvis. *Acta radiol.*, 1941, *22*, 422–424.

The author has previously described a case of rupture of the kidney pelvis by a stone and called attention to the rarity of such cases. In this article he describes a case in a woman of sixty-three who was admitted to hospital for severe pain in the left side of the abdomen and straining on urination. Roentgen examination showed the pelvis of the left kidney slightly distended, with relatively bulky calyces. The contrast fluid did not pass into the ureter normally but settled like a coating around the lower pole of the kidney and formed an irregular deposit on the median side of the pole. Evidently it had passed out through a rupture in the pelvis. Operation showed the rupture but did not show any stone, so the cause of the rupture is not known.

In this case the outlines of the psoas muscle were normal both in the roentgenogram and in the intravenous and retrograde pyelograms. The perinephritic changes had evidently not developed to such a degree as to obscure the outlines of the psoas. The perforation was judged to have taken place one day before the examination. In the previous case the outline of the psoas was obliterated and it was estimated that the perforation had taken place two days earlier.—*Audrey G. Morgan.*

WILLIAMS, E. ROHAN. Subcapsular rupture of the kidney—case report. *Brit. J. Radiol.*, July, 1941, *14*, 248–249.

A case of subcapsular rupture of the kidney is reported in woman of thirty-one who was knocked down by a motorcycle. She showed hematuria for four days after the accident but improved steadily and was discharged well one month after admission.

Plain films of the urinary tract on the fifth day after the accident showed general enlargement of the right kidney shadow. Excretion urography immediately afterward showed the upper calyces normal on the right side but the lower ones could not be defined. Forty-five minutes after the injection a vague opacity was seen at the lower pole of the right kidney apparently caused by extravasated urine but it gave little definite information in regard to the injury of the kidney. The next day a retrograde pyelogram was made. The contrast medium passed out from two ruptured calyces and collected in a puddle, the lower and lateral margins of which corresponded exactly to the lower outline of the kidney. The retrograde pyelogram showed exactly the site, nature and degree of the rupture.—*Audrey G. Morgan.*

ROBERTSON, T. D., and HAND, J. R. Primary intrarenal lipoma of surgical significance. *J. Urol.*, Sept., 1941, *46*, 458–474.

The authors found in the literature 12 intrarenal lipomas of such significant size as to be removed surgically. They add 2 new cases. Normally there is no fat in the kidney. Therefore the presence of a fatty tumor must be due to embryonal rests or fatty metamorphosis of multiplying perivascular and intertubular connective tissue cells. Intrarenal lipomata are to be distinguished from perirenal lipomata and replacement lipomatosis in a pyonephrotic kidney shell.

The first case reported by the authors was in a white female, aged twenty-nine, who complained of severe left loin pain, vomiting and localized tenderness. A left pyelogram showed an enlarged kidney with an elongated isthmus to the upper major calyx. The preoperative diagnosis was renal tumor. Histopathological examination of the tumor mass which was removed at operation showed a lipoma encroaching on kidney tissue with no intervening capsule.

The second case was that of a white female,

aged forty-eight, who had had no symptoms referable to the affected kidney. A left pyelogram showed elongation of the left kidney pelvis with lateral and caudad displacement of the kidney. A preoperative diagnosis of left renal tumor was confirmed at operation by the presence of a large lipoma in the upper pole. There was, as in the first case, no capsule separating the tumor from the kidney parenchyma.

The authors review the cases previously reported in the literature. These cases must be differentiated from renal cancer and this can only be done histologically. The prognosis is good in intrarenal lipoma.—*R. M. Harvey.*

Bugbee, H. G. Exploration of certain renal tumors. *J. Urol.*, July, 1941, *46*, 1–16.

Nephrectomy is the one cure for any type of renal tumor. This depends on an early diagnosis, which may be very difficult to make. Pain, hematuria and tumor are the classical symptoms and to them may be added urographic irregularities. Defects in the urogram which may simulate tumors are spasm of the pelvis or calyces, calculus, blood clot, air bubbles, mucus plugs, pus and caseous débris in the renal pelvis, deformities secondary to pyelonephritis, tuberculosis and pyonephrosis, renal carbuncle, cysts, torsion of the kidney, anomalies, extra-renal tumors and perinephritic abscess. The urogram should be repeated frequently in doubtful cases. In many cases surgical exploration is warranted where tumor cannot be ruled out.

The author cites illustrative cases of renal tumors with a paucity of clinical symptoms but evidence of some irregularity in the urogram. In each case operative interference revealed the true nature of the lesion. It is interesting to note that although clinical and cystoscopic findings may often be negative there is usually some defect in the urogram which arouses suspicion.

In cases with definite large inoperable renal tumors preoperative irradiation will often cause such marked reduction in the size of the tumor that later operation is possible.—*R. M. Harvey.*

Bugbee, H. G. Tuberculoma of the kidney; report of a case. *J. Urol.*, Sept., 1941, *46*, 355–358.

The patient was a white woman, aged thirty-five, who entered the hospital with chief complaints of frequency and dysuria and a history of gross hematuria and dull lumbar ache. Roentgen examination of the chest revealed no evidence of tuberculosis. A catheter could only be passed 1 cm. up the left ureter and the bladder urine contained acid-fast organisms which resembled the tubercle bacillus morphologically. Excretory urograms showed a normal right kidney and a filling defect suggestive of tumor in the left kidney. At operation the left kidney was removed and when split the pelvis was filled with a firm pinkish mass resembling a renal tumor.

Histological examination showed multiple discrete tubercles throughout the kidney and a tuberculoma in the renal pelvis. No necrosis or cavity formation had occurred. The authors were unable to find a case report of tuberculoma of the kidney in the literature.—*R. M. Harvey.*

Fowler, H. A. Bilateral renal ectopia; report of four additional cases. *J. Urol.*, June, 1941, *45*, 795–812.

Renal ectopia means a congenitally misplaced kidney with an anomalous blood supply. This condition must be distinguished from a ptotic kidney which has wandered from its normal position but has a normal blood supply. Fixation of the ectopic kidney helps to distinguish it from the ptotic kidney which is freely movable. The commonest surgically important anomalies of the kidney are horseshoe kidney, renal ectopia, crossed ectopia with and without fusion, and anomalies of rotation.

Renal ectopia may be unilateral, bilateral or crossed. In crossed ectopia one kidney is displaced to the opposite side and lies below its mate with or without fusion to its mate. Its ureter recrosses the midline and enters the bladder in the normal manner.

Bilateral renal ectopia is the rarest anomaly. The author found 36 previous case reports which, in addition to his 4, brings the total to 40. He reviews the previous literature and adds case reports of his 4 cases. Films of retrograde pyelograms and intravenous urograms are included to illustrate the anomalies.

The predominant clinical symptom is pain, which varies in intensity and suggests low abdominal pain rather than urinary tract pain. Symptoms of disease in an ectopic kidney are misleading due to the anomalous position of the kidney. The anomaly is not productive of pain unless associated disease is present.

Intravenous urography and pyelography are essential for a preoperative diagnosis. Treatment is the same as for the similar disease in a normally situated kidney.—*R. M. Harvey.*

HYAMS, J. A., and KENYON, H. R. Localized obliterating pyelonephritis. *J. Urol.*, Sept., 1941, *46*, 380–395.

The authors describe unusual changes which do not conform to the changes previously described in pyelonephritis. These changes are of an obliterative type, limited to one or more calyces and resulting in destruction of the calyx or its isolation from the true pelvis by a cicatricial barrier. The cause is extension of the infection to the submucosa. The authors were able to trace the development of these changes in several cases. They include several case reports with urograms to show the early changes which may lead to obliterative phenomena.

The characteristic urographic changes are loss of terminal indentation of the calyx, irregular contour, contraction of the lumen of the infundibulum and decrease in the diameter of the terminal portion of the calyx. Successive pyelograms will show increasing stenosis and shortening of the infundibulum with eventual disappearance of the calyx. Retrograde urography is necessary to demonstrate these changes.

Differentiation must be made from hydrocalyx, calyceal diverticulum and isolated tuberculous lesions.—*R. M. Harvey.*

PATERSON, RALSTON. Cancer of the bladder. *Brit. J. Radiol.*, July, 1941, *14*, 219–234.

Cancer of the bladder is relatively rare but it often occurs in young subjects and is an industrial disease of considerable importance.

There are various types of bladder cancer histologically but from the point of view of treatment the author thinks it preferable to use the macroscopic classification into benign papilloma and non-infiltrating and infiltrating cancer. Roentgen diagnosis can be made by simple cystography but he discusses a method, still in the experimental stage, called the relief pneumocystogram, which he thinks will prove valuable. Air, combined with a small amount of fluid but adhesive emulsion, is used to get a mucous relief picture. Illustrative cystograms and pneumocystograms are given.

The author believes that cancer of the bladder should be added to that group of cancers in which radiotherapy rather than surgery is to be considered the treatment of choice in all cases. Treatment may be either by implantation of radon seeds or radium needles or by radical deep roentgen treatment. The decision as to the kind of treatment to be used should be made before the bladder is opened. Radium should be used in small, solitary and well circumscribed growths and roentgen irradiation in multiple or large lesions. The decision should be made in advance because if roentgen irradiation is to be used the bladder should not be opened and if radon or radium implants are to be used the radiologist should stand with the implants in hand ready to apply them as soon as the bladder is opened. Diagrams showing the proper distribution of the implants is given. The dosage should be between 6,000 and 7,000 r. Seeds should never be implanted cystoscopically but the bladder should always be opened.

In roentgen treatment large doses should be given through small fields and a special mechanical method of directing the narrow beam should be used. Diagrams of the beam director and of the treatment fields are given.

Not enough cases are yet available for definite statistical reports but at the Holt Radium Institute, Manchester, 60 five year cases treated with intravesical radium are available. Of these 11 are alive and 10 of these are well and free of symptoms. Much more might be accomplished if early cases were treated. Of 64 three year cases 33 per cent are alive; of these 33 were early cases with a survival of 58 per cent and 31 late cases with a survival of 7 per cent. Of 17 two year cases treated with roentgen irradiation alone 5 are alive, well and free of symptoms.

Benign papillomata can be cured by a four-day twice daily course with full beam direction and a tumor dose of over 3,600 r. Another method of which the author has hope is the Chaoul contact or low voltage short distance therapy. The applicator can be fitted into the bladder and a single dose of 2,500 r given. The results in the few cases in which this method has been used have been good.

If radiotherapy is to be substituted for surgery in cancer of the bladder, radiologists must strive for perfection of technique and give up the old idea that radiotherapy is only palliative.—*Audrey G. Morgan.*

GREENFIELD, HENRY. Distant metastases from carcinoma of the urinary bladder. *Radiology*, Aug., 1941, *37*, 181–185.

Very few metastases from cancer of the bladder that could be demonstrated clinically or by roentgen examination have been reported because they generally occur late and in a large

percentage of the cases the patient dies from infection of the urinary tract before such metastases have had time to develop. Among 68 recorded cases of cancer of the bladder seen in the radiotherapy department of the Kings County Hospital there were 3 in which there was definite clinical and roentgen evidence of distant metastases. The author has seen another case in his private practice.

The histories and roentgenograms of these 3 cases are given. In 2 the metastases were in the lungs and in the third in the bones, involving both sides of the pelvis. The occurrence of metastasis does not depend on the size of the tumor or the degree of infiltration. Metastasis generally occurs by way of the blood rather than through the lymphatic system.—*Audrey G. Morgan.*

Clancy, F. J. Neoplasm complicating diverticulum of the bladder. *J. Urol.*, Sept., 1941, *46*, 486–490.

There have been only 50 cases of primary cancer occurring in diverticula of the bladder. The author adds an additional case in an eighty-three year old white male whose chief complaint was hematuria. A cystogram showed a large diverticulum arising from the right lateral bladder wall within which there was a filling defect suggesting tumor. At operation there was no evidence of carcinomatous invasion of the bladder wall although a malignant growth was found in the large diverticulum. The histopathological diagnosis was malignant papilloma.

The interesting feature of this case is that the diagnosis was suggested from the cystogram. The usual diagnosis by cystoscopic examination could not be made because of prostatic obstruction which prevented introduction of the cystoscope.—*R. H. Harvey.*

Collings, C. W., and Welebir, F. Osteoma of the bladder. *J. Urol.*, Sept., 1941, *46*, 494–498.

The authors were able to find no case reports in the literature back to 1916 of osteoma of the bladder. Their case was that of a sixty-seven year old colored female who complained of frequency, burning and dribbling of six years' duration and hematuria of three months' duration. Just prior to the onset of her symptoms she had received radium and deep roentgen therapy for a carcinoma of the cervix. A survey film of the bladder area showed several round calcified bodies suggesting calcifications in fibroid tumors of the uterus. Through a suprapubic incision six bony masses which were stuck to the bladder mucosa were removed. The histopathological diagnosis was probable osteoma of the bladder.

The authors offer as a possible etiological factor thrombosis of the blood vessels of the bladder secondary to the previous irradiation for cervical cancer. The patient was free from bladder symptoms one year following the operation.—*R. M. Harvey.*

Strauss, B. The roentgen demonstration of the prevesical spaces. *J. Urol.*, Sept., 1941, *46*, 520–527.

The technique of the author in demonstrating the prevesical spaces is to prepare the suprapubic region as for cystotomy. The skin, underlying tissues and peritoneum down to the bladder were anesthetized with novocaine. The bladder was catheterized, lavaged with sterile water and then filled to capacity with sterile water and the catheter clamped. A 21 gauge, 3 inch hypodermic needle was then introduced into the bladder in the midline just above the pubis. As soon as the needle entered the bladder it was withdrawn until its point rested just outside the bladder. The bladder was then emptied and 30 cc. of diodrast introduced slowly through the hypodermic needle into the prevesical space. A survey film was exposed centering over the bladder. Then the bladder was filled with air and an air cystogram made. Various combinations of films were made in several positions. No complications occurred. The solution could be demonstrated in the kidney pelves in thirty minutes and was totally absorbed in one hour.

The author describes minutely the anatomy of the prevesical spaces. The various appearances which may be assumed by the injected medium in the prevesical spaces are demonstrated by films. The three main areas which could be demonstrated by this method are the retropubic, preperitoneal and perivesical.—*R. M. Harvey.*

Katzen, P. Metastatic carcinoma of the epididymis; report of a case. *J. Urol.*, Oct., 1941, *46*, 734–739.

Only 2 cases of metastatic carcinoma to the epididymis have been reported in the literature. These 2 cases both had their primary site in the kidney. The author adds an additional case which occurred in a white male, aged forty-one,

who was admitted to the hospital complaining of upper abdominal pain, nausea and vomiting. He had lost 27 pounds in six weeks. Gastrointestinal examination revealed a large carcinoma in the pyloric end of the stomach, which was confirmed at operation. The histopathological diagnosis was colloid adenocarcinoma of the stomach. Three months later he was readmitted with a painless swelling of the right side of the scrotum. On physical examination the right epididymis was enlarged and hard. The right vas was also thickened and hard.

At operation an enlarged firm epididymis was removed. The histopathological report was metastatic adenocarcinoma.—*R. M. Harvey.*

HERGER, C. C., and SAUER, H. R. Relationship of serum acid phosphatase determination to presence of bone metastases from carcinoma of prostate. *J. Urol.*, Aug., 1941, *46*, 286–302.

Many cases of carcinoma of the prostate show bone changes which often cannot be definitely stated to be metastatic. Frequent examinations to note changes in the appearance of the lesions may be necessary before a positive diagnosis can be made. Recent work suggests that the phosphatase activity of the blood serum may be of diagnostic and prognostic value. The authors routinely examine the pelvis, lumbar spine and chest for evidence of prostatic cancer. Recently they have been making phosphatase determinations.

The enzyme phosphatase liberates phosphate ions from phosphoric acid esters. The authors use the method of King-Armstrong rather than that of Bodansky. Gutman and Robinson have shown that phosphatase was increased in 37 out of 44 cases of carcinoma of the prostate with metastatic bone changes regardless of whether the changes were of the osteolytic or osteoblastic type. No elevation of blood phosphatase occurred in the absence of metastases. This was acid phosphatase as opposed to increase in alkaline phosphatase which occurred in Paget's disease. They set an arbitrary value of 3.0 units with the King-Armstrong method as the limit. If the phosphatase exceeded this value metastases were probable even in the absence of visible bone changes and if the value was below this level metastases were unlikely even in the presence of suspicious bone changes.

The authors have attempted to determine the reliability of the acid phosphatase determinations as indicators of bone metastases in cancer of the prostate. One hundred patients were examined, 69 with cancer of the prostate and 28 controls. Three cases were in doubt. Thirteen cases had definite bone metastases and every case had acid phosphatase values above the arbitrary 3.0 units, the average being 22.24 units. In 9 of the 13 cases alkaline phosphatase was also increased. They found no distinction in phosphatase values in osteolytic and osteoblastic types of metastases. In 19 of the remaining 87 cases values above 3.0 King-Armstrong units were found. Four of these cases had areas suggesting metastases in the pelvis. Nine cases had cancer of the prostate with no evidence of metastases. The authors do not feel that Gutman, Gutman and Robinson are justified in setting their arbitrary figure of 3.0 King-Armstrong units as top normal. They suggest 4.0 units for this value. They also believe that the findings should show a tendency to rise on repeated examinations if definite bone metastases are present. They had only one patient with definite bone metastases and a normal acid phosphatase determination.

In conclusion, the authors believe that the acid phosphatase values of the blood serum are of definite diagnostic aid in metastatic bone lesions from carcinoma of the prostate. Values below 4.0 King-Armstrong units should be considered normal. Values from 4.0 to 6.0 units should be interpreted with caution. They feel that values above 6.0 units indicate metastatic bone involvement from cancer of the prostate. A rapidly progressing elevation of the acid phosphatase activity should be regarded as an unfavorable prognostic sign.—*R. M. Harvey.*

SEAMAN, J. A., and BINNIG, C. Urological complications of cancer of the rectum. *J. Urol.*, Oct., 1941, *46*, 777–787.

Cancer of the rectum can be palpated by rectum in 85 per cent of cases. This is of interest to the urologist who makes use of rectal palpation more often than the other specialists. The close relationship of the rectum and urinary tract render the latter vulnerable to rectal cancer and the operative measures connected with it. The ureters may be traumatized, ligated or sectioned in abdominoperineal operations on the rectum. The sympathetic or parasympathetic nerve supply may be injured, producing an atonic bladder with relaxed sphincter. The bladder usually suffers severe trauma in being separated from the rectum. Bladder in-

fections are a frequent sequel to rectal operations.

Cancer of the rectum rarely invades the prostate gland. Occasionally rectal cancer may invade the bladder. Usually the symptomatology of the primary lesion will overshadow the symptoms of a secondary obstructive uropathy.

After operative removal of the rectum for cancer it is no longer possible to make an early diagnosis of prostatic cancer by rectal palpation. This raises the question of the advisability of doing a routine prostatectomy in rectal cancer although no disease of the prostate may be present.—*R. M. Harvey.*

SKELETAL SYSTEM

Howes, William Edward, and Schenck, Samuel George. Roentgenologic considerations in the diagnosis and treatment of primary malignant bone tumors. *Radiology*, July, 1941, *37*, 18–34.

The authors present a study of 40 primary malignant bone tumors. They were, according to Ewing's classification, osteogenic sarcoma 24 cases, chondrosarcoma 3 cases, endothelioma 5 cases, multiple myeloma 3 cases, reticulum-cell lymphosarcoma 4 cases, unclassified 1 case. The age range of the patients was from two and one-half to seventy-two years, the average being 32.6 years. The average duration of symptoms before the beginning of treatment was about six and one-half months.

Roentgen examination proved to be one of the surest methods of diagnosis. Roentgenograms of illustrative cases with descriptions of the typical findings in the different forms of tumor are given. Among the 39 cases examined roentgenologically the diagnosis proved correct in 33. One case was diagnosed as osteochondroma instead of osteochondrosarcoma, 1 as metastatic malignancy instead of lymphosarcoma, 1 as metabolic dyscrasia instead of leukosarcoma, in 1 no roentgen diagnosis was ventured but it proved to be reticulo-endothelioma, 1 was diagnosed as cortico-periostitis of the ulna but proved to be angio-endothelioma, and in 1 case of parosteal osteogenic sarcoma the roentgenograms taken postoperatively proved negative.

Treatment cannot be standardized at present. Among these cases 35 were given irradiation or operation or both. Twenty-six patients were benefited for from one month to four and one-half years, including the 13 still alive, giving a mean average of 15.4 months' alleviation of symptoms. The other 9 showed no clinical improvement from either surgery or irradiation. Up to the present time 25 of the patients are dead, 2 have not been followed and 13 are living. The present survival period in these 13 cases, dating from the beginning of treatment, is from three months to six years, the mean average being twenty and one-half months.

In the discussion Dr. Murphy said that the usual classifications of bone tumor are pathological but he thinks that pathological diagnosis is just as difficult as roentgenological. It should be remembered that anteroposterior and lateral views are often not sufficient. Stereoscopic, tangential and other types of views should be made to bring out all possible information. If such care is taken he thinks the roentgenologist will be as successful as the pathologist in diagnosis.

Dr. Newell said that either irradiation or surgery may fail. A Ewing tumor might be cured by either irradiation or amputation and the patient die from remote metastases. This does not prevent his preferring irradiation for Ewing's tumor.

In closing Dr. Howes said that the danger from biopsy was slight as compared with its value in diagnosis. Brailsford advocates immobilization of the limb and follow-up examinations when diagnosis cannot be made from the original examination. Dr. Howes thinks the danger from delay is greater than that from biopsy.—*Audrey G. Morgan.*

Campbell, Willis C., and Hamilton, J. F. Gradation of Ewing's tumor (endothelial myeloma). *J. Bone & Joint Surg.*, Oct., 1941, *23*, 869–876.

Campbell and Hamilton state that the available literature contains no record of an attempt to grade Ewing's tumor. So a serious study was made of 30 cases, particularly with reference to microscopic findings of the tumors, in an effort to find reliable data which would aid in grading the malignancy of this entity. They regard the grading of this tumor, as of carcinoma and sarcoma, as exceedingly difficult. A number of factors are responsible for this difficulty, especially the total lack of differentiation of the tumor cell. The prognosis, therefore, should always be guarded.

They conclude that the most significant of their findings is the nuclear chromatin content,

and the cell activity as measured by the number of mitotic figures per high-power field. A classification of the tumors according to their chromatin content indicates that those containing a large number of chomatin knots are probably more malignant than those containing a lesser number.

In studying the cellular activity, they divided the tumors into three grades, according to the number of mitotic figures in a high-power field, as follows: Grade 1, one to five figures; Grade 2, six to ten figures; and Grade 3, eleven to fifteen figures. It appeared that a patient with a tumor having five or less mitotic figures (Grade 1) has approximately a 23 per cent chance to survive ten years and a 31 per cent chance to live five years, whereas, if the mitotic count is eleven or above (Grade 3), he will probably live little over a year. None of the patients with tumors in Grade 2 of the series lived ten years, and 3, or 33 per cent, lived over five years.

The roentgenographic evidence presented by their cases indicated that the early stage, characterized by bone condensation, goes hand in hand with increased cellular activity, whereas late bone changes are usually accompanied by diminished cellular activity.

They regard this group of cases as too small to draw any definite conclusions regarding the gradation of Ewing's tumor. Studies of large numbers of cases may throw more light upon the subject and lead to the discovery of a method of establishing a more accurate prognosis.—*R. S. Bromer.*

AITKEN, A. P. Roentgenographic recognition of synovioma. *J. Bone & Joint Surg.*, Oct., 1941, *23*, 950–952.

The tumor which was present in the case reported by Aitken was one that is derived primarily from the cells of the synovial lining, and which is characterized by the formation within the tumor of spaces lined with synovial cells. The tumor is said by pathologists to resemble closely an angioma, and is often mistaken for it. This neoplasm is a sarcoma, and is either highly malignant or potentially so. Although the tumor is derived from synovial cells, and may thus arise from either a joint or bursa, it may be found to be entirely extracapsular, and to have no apparent association with either of these structures. However, it is usually found in close proximity to a joint.

Lewis has described the roentgenographic appearance as follows: "Near a joint, and sometimes involving the joint, is seen a rounded, sometimes rather lobulated, sharply defined, soft-tissue tumor mass. No differential diagnosis can be made on such a mass itself; but when in the mass is found a scattered and irregular deposit of amorphous lime, we have learned that a provisional diagnosis of synovioma is justified." Aitken's case showed in the roentgenograms of the knee joint amorphous areas of calcification with definite extension into the joint space and with no evidence of bone involvement. His patient was operated upon and the tumor was removed, but sixteen months later examination showed multiple metastases to the lungs.—*R. S. Bromer.*

KIBBY, SYDNEY V. Melorheostosis, with report of a case. *Radiology*, July, 1941, *37*, 62–67.

Melorheostosis is a type of hyperplasia of bone limited to one extremity and extending from one end of it to the other but usually leaving a few unaffected areas along its course.

The author reviews the few cases previously published and describes a case of his own in a Japanese girl, five years old when first reported in 1931. Illustrative roentgenograms are given. The patient had difficulty in walking and some valgus deformity of the knee. The onset had been gradual. She had had slight pain in the knee at times. The child had been late in starting to walk and had a slight limp. Roentgenograms showed linear areas of increased density extending from the head of the left femur along the medial and anterior surface of the shaft to about a quarter of an inch above the distal epiphysis. There was spotty condensation in the patella and the upper epiphysis of the tibia. A streak of condensation extended down the lateral and anterior surface of the tibia to the lower epiphysis. The fibula was not involved. There were areas of condensation in the astragalus and traces in the os calcis, navicular and first metatarsal. There appeared to be arrested development of the epiphyses of the involved bones. Six years later roentgenograms did not show any increase in the extent of the lesions or any changes in their distribution.

The cause of the condition is not known. Zimmer's theory that it is due to a congenital developmental defect in a primitive segment explains the distribution and the early occurrence of most of the cases but does not account for the disease in adults.—*Audrey G. Morgan.*

Camp, John D., and McCullough, J. A. L. Pseudofractures in diseases affecting the skeletal system. *Radiology*, June, 1941, *36*, 651–663.

Pseudofractures occur in various forms, either as transverse zones of decalcification, cracks or fissures extending through the cortex to one side or as fusiform callus formation and periosteal reaction. They seem to develop without gross trauma but trauma may convert them into true fractures. Attempts have been made in recent years to show that these pseudofractures constitute a new and independent disease entity. The author does not believe that this is true as they occur in many conditions that are not closely related. The greatest number of cases were reported in the years immediately following the world war, indicating that in some cases at least they are caused by malnutrition. The author concludes that they are caused by excessive strain on bones that are already weakened by disease. They occur most frequently in the bones that are subjected to the greatest strain. Experimental work has been done that seems to confirm this theory.—*Audrey G. Morgan.*

Hart, Vernon L. Two unusual injuries of the wrist. *J. Bone & Joint Surg.*, Oct., 1941, *23*, 948–949.

Hart records two unusual injuries of the wrist resulting from direct violence over the volar aspect of the carpus. The first injury is a fracture of the ridge of the greater multangular bone or trapezium which gives attachment to three of the intrinsic muscles of the hand and the transverse carpal ligament.

The second injury which he describes is a scar-tissue ring constricture of the ulnar nerve where it passes over the hook of the hamate or unciform bone which forms a part of the ulnar border of the carpal canal. Excision of the ring of scar tissue and a neurolysis of the affected portion of the nerve resulted in complete relief of the patient's disability.—*R. S. Bromer.*

Carter, Ralph M. Carpal boss: a commonly overlooked deformity of the carpus. *J. Bone & Joint Surg.*, Oct., 1941, *23*, 935–945.

Carter's first patient presenting the condition known as "carpal boss" was a woman, aged thirty, who had a definite rounded tumor on the posterior aspect of the right wrist situated at the base of third metacarpal bone. It was firm in consistency, was painless upon pressure, and was apparently firmly attached to the underlying bone. The skin was freely movable above it. The tumor was approximately 1 cm. in diameter and was much more apparent with the hand in extreme palmar flexion. A lateral roentgenogram showed that the tumor was a definite outgrowth of bone posteriorly from the distal articular surface of the os capitum of the wrist, and a similar outgrowth from the proximal surface of the third metacarpal; in other words, there seemed to be a fully developed posterior "lipping" of the articular surfaces of both bones, with complete preservation of the articulation itself. The patient was operated upon and the condition found at operation was that shown in the roentgenogram. The spurs were removed and the symptoms disappeared. Within a few months the tumor had reappeared, and the roentgenogram revealed that the preoperative condition had recurred. However, there has been no recurrence of symptoms and the tumor, having again attained its original dimensions, has since shown no tendency to increase is size.

Carter has seen 5 more patients with the same condition. Investigation of the literature showed that the process was a definite clinical entity, but one which apparently has only been described in the French medical literature. The causes assigned to the process are speculative, and it has not been sufficiently studied to prove or disprove the various etiologic theories. The fact that the deformity always occurs in the same location, and that it always presents the same roentgenographic appearance, would indicate that some etiologic factor is present which is common to all; as, for instance, it would appear extremely likely that this common factor might be an occupational one. However, a study of Carter's cases would seem to indicate that the various occupations of his patients had nothing in common, which would tend to disprove this suggestion. That the cause which originally produced the condition probably remained active is shown by the fact that the exostoses promptly recurred after removal.

Carter states that two considerations prompted his report. In the first place, the disease is of interest from the academic standpoint. It is apparently a sharply defined clinical entity, and probably more common than a search of the literature would indicate. Even though it is a comparatively trivial affection, orthopedic surgeons should have it in mind and be able to recognize it when it presents itself, if only for the purpose of differential diagnosis.

In the second place, and probably of more importance from a practicable standpoint, is the fact that disability claims may arise following industrial accidents, as in one of his patients. In the published cases and in Carter's own experience, there is nothing to indicate that the condition follows a single trauma in the affected region. On the contrary, it appears to be a gradual development.

He believes that these patients should not be operated upon.—*R. S. Bromer.*

CAVE, EDWIN FRENCH. Retrolunar dislocation of the capitate with fracture or subluxation of the navicular bone. *J. Bone & Joint Surg.*, Oct., 1941, *23*, 830–840.

Dislocation of the capitate bone, with fracture or subluxation of the navicular, has been third in frequency in the series of carpal bone injuries at the Massachusetts General Hospital. It is, however, far outnumbered by fractures of the navicular bone and dislocations of the lunate. Reduction of the dislocation of the capitate by manipulation can be accomplished if done early. If this is not successful, open reduction must be carried out. If there is an associated navicular fracture, and satisfactory alignment of the fragments is not obtained by manipulation, Cave advocates open reduction and insertion of a bone graft. In neglected cases of this type of injury, he advocates a choice of treatment between excision of the first row of the carpus and wrist fusion.—*R. S. Bromer.*

SOTO-HALL, RALPH, and HALDEMAN, KEENE O. The conservative and operative treatment of fractures of the carpal scaphoid (navicular). *J. Bone & Joint Surg.*, Oct., 1941, *23*, 841–850.

The authors conclude that success in the treatment of fractures of the carpal navicular depends upon the recognition of the fracture within two or three weeks of injury, and upon adequate and prolonged immobilization. Under these favorable conditions osseous union may be anticipated in a very high percentage of cases.

Excision of one or both fragments of the navicular is reserved for a limited number of cases, including those showing marked comminution and those in which other measures have failed.

From further experience in the operative treatment of non-union, they believe that the drilling operation has a limited value, and that a procedure is indicated which combines the excision of the interposed fibrous tissue, the drilling of the bone, and the insertion of a bone graft from the radius. This procedure materially reduces the period of necessary immobilization and increases the chances of union.—*R. S. Bromer.*

SACHS, MAURICE D., HILL, HAROLD A. and CHUINARD, ELDON L. Further studies of the shoulder joint with special reference to the bicipital groove. *Radiology*, June, 1941, *36*, 731–735.

The usual roentgen projections fail to show bone changes in the region of the bicipital groove. The authors suggest a projection with the central ray tangential to the bicipital groove. The angulation varies with the thickness of the patient but medially it is approximately from 25 to 30 degrees and ventrally from 10 to 15 degrees. The patient is supine with the arm adducted and supinated; the cassette is on top of the shoulder and at right angles to the longitudinal axis of the humerus, the tube slightly external to and below the elbow.

Such views were made of 40 patients with a history of trauma to the shoulder but in whom routine roentgenograms were negative. The grooves were not normal in any of the cases. Four of the cases are described and illustrated with roentgenograms to show the nature of the abnormalities found. It will require further study and correlation of the clinical and roentgen findings to determine the clinical significance of these roentgen changes.—*Audrey G. Morgan.*

Cornelius Packard Rhoads
Caldwell Lecturer, 1942